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(54) **Vermicomposting system.**

(57) A composting plant e.g. for use in vermiculture, comprises a cruciform-type breaker bar unit 16 (Figure 4) for moving the bottom layer of compost through the perforated floor of the plant. Alternative designs of breaker bar unit are also described.

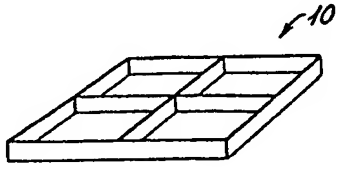

Fig. 1

EP 0 196 887 A2

SOLIDS DISCHARGE DEVICE

The present invention relates to a solids discharge device and in particular, but not exclusively, to one for discharging friable and/or particulate material from a container e.g. as part of a vermicomposting system for commercial scale vermiculture.

Whilst the aim of vermicomposting is the improvement of wastes into a useful or marketable product, the production of worms is another result of the process as these have a high protein content and when separated from the processed waste, can be used as a feed additive, e.g. for fish farming, or for pigs or poultry.

To date, two production systems have been in use. The simplest is a batch system where a quantity of waste is inoculated with worms and left until the waste has been broken down. The more successful system, however, is a cumulative-batch layer-fed system. Here a smaller quantity of waste is inoculated with worms and as it becomes broken down another and successive layers are added. In both systems, waste and worms are 'harvested' in one operation when the whole is removed and another batch is then started.

Machines are already known which use one or more augers for discharging compost from a compost bin but such arrangements are expensive for large-area bins and also less than satisfactory in a vermicomposting system, for example, where, ideally, worked material should be extracted from the lowermost layers of the charge with only negligible disturbance of the upper worm-containing layers of material.

On-farm (non-worm) composting is also being considered, and here the possibilities contemplated at present are the use of expensive screw-auger discharge vessels or simple in-pile composting. The latter option tends to give an inconsistent product but the expense involved in the former makes it inappropriate.

In addition, problems are often experienced in obtaining slow, even feed of other difficult solids which display severe bridging, e.g. moist soils in soil processing lines, etc. Commonly used equipment comprises a hopper with vertical or near-vertical sides astride a very heavy duty belt conveyor of the roller bed type, with massive drive and idler drums powered by a very high torque variable speed drive. Flow rate is determined by a combination of belt speed and restriction of the hopper front aperture. Flow of material through the aperture requires massive shearing forces to be generated.

An object of the present invention is to provide a discharge device by which the disadvantages outlined above for existing systems may be avoided or at least significantly reduced.

Another object of the patent invention is to provide a continuous vermicomposting system rather than the batch systems referred to above.

According to the present invention, a discharge device e.g. for a friable and/or particulate material, comprises a container having an apertured floor, one or more material-displacing members engaging with or lying adjacent to the upper surface of the floor, and drive means for moving the one or more members bodily across the floor thereby to urge material in the container downwardly through the apertures in the floor.

Conveniently, the container is square or rectangular when viewed in plan, the one or more material-displacing members comprising an elongate member lying parallel to the length or width dimension of the container, and the drive means is operative to move the elongate member in directions parallel to the other of these two dimensions.

Conveniently, the elongate member spans or substantially spans the container.

Conveniently, the elongate member has a rectangular or domed cross-section.

Conveniently, the elongate member inclines upwardly at each end.

Conveniently, the elongate member includes one or more vertical tines.

Conveniently, the or each tine comprises a flat e.g. triangular, vertical projection having its main plane aligned with the direction of movement of the elongate member through the container.

Conveniently, the or each tine is apertured and the device includes aerating means for supplying air to these apertures.

Conveniently, the aerating means comprises an air-supply tube through which air from a pump is provided to the tines e.g. via an air-supply reel.

Conveniently, the elongate member referred to above comprises a first such member and the one or more material-displacing members includes a second elongate member arranged at right angles to the first member.

Conveniently, the first and second material-displacing members are arranged so as in plan view to provide a simple cruciform structure, preferably unbraced.

Conveniently, the overall length of the second elongate member is not less than about two thirds the overall length of the first elongate member.

Conveniently, the second elongate member inclines upwardly at each end.

Conveniently, the drive means comprises a winch or chain and sprocket system e.g. with the cable or chain, as the case may be, attached to either end of the second elongate member (when present).

Alternatively, the drive means may comprise one or more rams or other linear activators.

The invention also includes a vermicomposting system incorporating a device according to the present invention and in particular, but not exclusively, a continuous vermicomposting apparatus comprising a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of the charge and discharge means according to the present invention for removing from the bottom of the charge quantities of the material processed by the worms in the container.

Conveniently, the floor of the container is apertured and the discharge means operates by forcing worm-processed material through the apertures in the container floor.

Conveniently, in this case, the discharge means comprises an elongate member adapted to traverse the upper surface of the container floor laterally.

Alternatively, the floor of the container may comprise a plurality of longitudinally finned or otherwise shaped elements of non-circular cross-section co-operating to provide a floor to the container and rotatable about their longitudinal axes to encourage material from the container to pass through the container floor.

Conveniently, in this case, the elements are spaced apart to provide the container with an apertured floor and rotation of the elements about their axes encourages material to pass through the apertures in the container floor.

Conveniently, the apparatus includes drive means operative to rotate the elements in a to and fro motion.

Conveniently, the apparatus includes fan means operative to provide a flow of aerating and/or heating air to the undersurface of the charge.

Conveniently, the apparatus includes means for supplying supplementary heating to the middle and/or upper layers of the charge.

Conveniently, the apparatus includes feed means operative to break up lumps in a supply of unprocessed material before loading it onto the upper surface of the charge.

Conveniently, the apparatus includes means for watering the upper layers of the charge.

Conveniently, the apparatus includes enclosure means operative to prevent overwetting of the charge by rain when the apparatus is installed in the open air and to discourage the excessive evaporation of water from the charge in dry conditions.

It is to be noted that the term 'apertured' as used above and in the claims is to be broadly interpreted as describing any non-continuous floor for the container, i.e. any floor not wholly closing off the bottom end of the container.

The invention further includes a bedding system for animals, or a feed hopper, when incorporating a discharge device according to the present invention.

According to another aspect of the present invention, a continuous vermicomposting apparatus comprises a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of the charge and discharge means according to the present invention for removing from the bottom of the charge quantities of the material processed by the worms in the container.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:-

Figures 1, 2 and 3 are perspective views of different designs of apertured floor for use in a vermicomposting system;

Figure 4 is a perspective view of a cruciform unit for displacing material through the apertured floors of Figures 1 to 3;

Figures 5 and 5a show alternative drives for moving the unit of Figure 4 from end to end of a container;

Figure 6 is a vertical section of one or other of the material-displacing members used in the unit of Figure 4, and Figure 6a shows a similar section of an alternative design;

Figure 7 shows an alternative design of soil-displacing unit to that shown in Figure 4;

Figure 8 shows a modification of the design of Figure 7;

Figure 9 illustrates how the invention may be applied to a bedding system for animals;

Figure 10 shows a schematic vertical section through a first embodiment of the apparatus in accordance with the present invention;

Figure 11 shows a schematic perspective view of a first discharge device for use in the apparatus of Figure 10;

Figure 12 is a vertical section of part of an alternative discharge device to that shown in Figure 11;

Figure 13 is a schematic side view of a feed hopper for use with materials that display severe bridging;

Figures 14 and 15 are respectively side and end views of an underfloor collection scaper for use with the apparatus of the earlier Figures. and

Figure 16 is a schematic perspective view of a drive system for use in some embodiments of the invention.

Thus referring first to Figures 1 to 3, these show three alternative designs of apertured floor for the container of a continuous vermicomposting system, namely a grid 10 (Figure 1) a mesh 12 (Figure 2), and a slanting bar construction 14 (Figure 3). In all these designs, the spacing between adjacent floor members (measured perpendicularly to these members) would typically be of a value of from 75 mm up to 200 mm, say.

Figure 4 shows a simple form of breaker bar unit 16 comprising two elongate members 18, 19 arranged in a simple unbraced cruciform construction.

Lugs 21, 22 extending upwardly from member 18 allow the construction to be pulled in a direction parallel to this member across the floor of the container.

The cross-member 19 is dimensioned so as to span or substantially span the container and the length of member 18 is preferably not less than about two thirds of the length of member 19.

In the illustrated embodiment, in fact, the separation l of each lug 21, 22 from the adjacent edge of cross-member 19 was designed to be not more than one third the length w of the member 18.

As illustrated in the drawing, both members 18, 19 incline upwardly at either end e.g. at about 30^{o} to the horizontal.

Turning now to Figures 5 and 5a, these show alternative designs of drive system for use in a layer composting system of,

say, 50 to 75 square metres (corresponding respectively to containers of 20 metres to 30 metres length, say). In significantly smaller systems e.g. containers of 4 to 9 square metres area, a simple hydraulic ram or similar linear activator may be employed e.g. as shown in the arrangement of Figure 3 to be described hereinafter. A modified ram or linear activator system may be used to drive intermediate size soil-displacement units, such as shown, for example, in Figures 8 to 10 still to be described in detail below. One example of thiks latter type of drive system will be hereinafter described with reference to Figure 16.

Returning now to Figure 5, the drive system 24 comprises, in essence, a winch 26 and idler pulley 27, one at either end of the container 29. A steel cable 31 attached to lug 21 passes around the winch 26 and then underneath the container floor 33 and back around the idler pulley 27 for attachment to the second lug 22. In the drive system 35 of Figure 5a the steel cable 31 is replaced by a chain 37 and the winch 26 and idler pulley 27 are replaced by a sprocket drive 39, 40. In alternative drive systems (not shown), both rotary supports can be driven.

A force of around 3000-4000N per metre width w of the cross-member 19 will be required to draw the soil-displacement unit horizontally across the perforated floor of the container and discharge material therethrough without becoming obstructed by any small stones etc. present in the soil.

Waste rests on the perforated floor of the container because of its characteristic tendency to bridge, and the size of the perforations is chosen as the minimum required to ensure the support of the material. On the initial loading, inevitably some material will pass straight through.

In operation, when drawn over the container floor beneath the waste layers in a vermicomposting system, the breaker-bar unit will set up shearing of waste along a line forward of itself. The waste lying below this line is disturbed and its movement results in a localised breakdown of the bridging by which it is supported on the container floor, hence the terminology 'breaker' bar.

Waste above the line of shear remains substantially undisturbed so that worm activity is unaffected. However, there is a 'heaving' effect as the bar passes through and this causes some fissuring of settled waste which is beneficial for maintaining aerobicity of the waste. Vetical leading edges of the bar are essential but the bar may be flat topped (Figure 6) or crowned (Figure 6 a) to give more heaving. Because the bar operates in both directions it must always be of uniform cross-section.

Turning now to the case of a (non-worm) composting reactor, this would have to be deeper than those used in vermicomposting to achieve the higher composting temperatures required and certain modifications to the discharge equipment so far described would be desirable. Figure 7 shows a breaker bar 42 particularly suited for this different environment insofar as vertical triangular tines 44, 45 are now provided to entrain air into the waste. In a variation, hollow tines 47, 48 with internal air feed are used to give localised forced aeration on every breaker pass as shown in Figure 8 where reference numerals 50, 51 respectively indicate a tube and air-supply reel for supplying air to the tines.

Figure 9 illustrates another possible use for the equipment. Increasing pressure exists to return to the bedding of animals on straw. However accumulating layers of bedding make the use of fixed height feeders and waterers impossible. In the arrangement of Figure 10, however, a breaker bar 53 of massive construction running on a large grid floor 55 e.g. 200 x 200 mm, could break out the lower layers of farmyard manure leaving stock on a pleasant insulating and well drained layer of the manure.

General advantages associated with the illustrated embodiments of the present invention are: low cost, particularly on long containers; true horizontal-layer discharge; the mechanically-broken discharged layer is suited for easy subsequent handling or mixing; some 'heaving' of the waste can take place to provide air entrainment, but without stirring up the worm-active layer in the vermiculture applications; and progressive discharge over the container floor area occurs resulting in low actuating

forces. In addition, the grid mesh or slanting-bar design of floor on which the waste is supported has two features which are very important, namely those of allowing air movement into the waste and some draining of any excess water in the waste.

Referring now to Figures 10 and 11 of the drawings, a continuous vermicomposting apparatus 110 according to the present invention comprises a container 112 for a charge of worm-containing organic farmyard waste 114.

The organic waste is loaded or fed to the top of the container in thin layers (typically 20 mm) by a gantry-mounted manure-spreading trolley 116 extending across the full width of the container and able to traverse it from one end to the other. The trolley also serves to break up any lumps initially present in the material. In an alternative arrangement (not shown), the container 112 is loaded from the discharge floor of a reception vessel e.g. in the form of a travelling hopper, positioned over the top of the container.

Reference numeral 118 indicates the floor of the container. This is preferably of an open mesh construction as best seen from Figure 11. Typically, for example, the floor might be provided by a 50 mm square or 75 mm square galvanised steel mesh through which processed waste can be discharged by a chain-drawn breaker bar 20 (shown only in Figure 11).

As will be clear from the drawing, the bar 120 extends across the width dimension of the container floor and, in operation, winch units (not shown) will move it transversely from end to end of the floor, typically at about 1000 cm per minute. With the mesh sizes quoted above and up to about 1.25 metre width, say, the breaker bar might typically be formed from flat steel bar of 50 mm x 6 mm cross-section. For a 2.5 metre width container, the corresponding bar cross-section might typically be 40 mm x 12 mm, say.

As an alternative to a mesh floor, closely spaced parallel bars may be used instead if desired.

Clearly, the container floor 118 must be raised above ground level to provide a collection space 119 for material forced through the mesh by bar 120. At other times, at least the lower layers of material in the container can be aerated, and optionally also dried to some extent, by a fan 122 adapted to provide a blast of cold or hot air beneath the floor 118. This will also be effective in drying out previously discharged matter prior to its removal from beneath the container.

Supplementary heating is also possible if desired, e.g. by electric cables (not shown) mounted at a mid or upper position in the container. Conveniently, these heating cables will be wound around tensioned steel support cables passing from side to side and/or end to end of the container.

Conveniently, the apparatus is completed by thermal insulation and an enclosure (not shown) to prevent overwetting when the container is installed in the open air. The presence of the enclosure will also discourage excessive evaporation of water from the waste in dry weather though a spinkler system (not shown) is also preferably provided as a safeguard to water the upper layers of waste 114 should conditions require. In the event of excess water being provided, this can freely drain through the floor mesh of the container.

In operation of the apparatus, the container 112 is loaded with worm-containing waste as described and the temperature, aerobicity and dampness of the material waste is adjusted if required for optimum conditions.

The high population of worms within the container (typically 3 to 6 Kg of worms per square metre of material) will continually refine the waste, breaking it down to a smaller particle size.

The worms will continually move upward to new layers of waste as the previous layers become exhausted. Discharge of processed waste through the floor of the container takes place at substantially similar intervals to those at which new waste is added to the top, maintaining a fixed amount of continually renewed waste for processing in the container.

Because worms move up to the fresh waste layers, the processed waste will be substantially worm-free and can be discharged through the floor as already discussed for recovery by scraper, conveyor, skip or other suitable means.

In running the apparatus, the aim is always to maintain a high population of worms and achieve maximum throughput of waste.

A typical weekly output of vermicompost when using separated solids waste derived from cattle slurry is about 0.08 cubic meters per square metre of floor space of the apparatus.

In cases where the retention time of waste in the container is only four or five days, the waste throughput is too fast to enable worm cocoons to hatch and grow in the container and they will be lost in the discharged waste. In this case some addition of small worms may be necessary to maintain the desired level of performance.

Conversely, if the waste is passing so slowly through the apparatus as to give a waste retention time of 30 to 40 days, for example, the same worms will need to be harvested from the top layer of the material to prevent a continually expanding worm population.

Where wastes are strongly self-heating due to microbial degradation, careful control of feed layer depth and retained depth should be practised with the aim of keeping temperature at the 20-25°C optimum. In particular, overheating to above 30°C should be avoided as above this temperature damage to the worms may result.

With the discharge system of Figure 11, movement of the bar across the container floor causes localised breakdown of bridging of contained material and discharge results as the bar advances. However, Figure 12 shows an alternative design of discharge mechanism in which the container floor consists of finned metal square-section elements 124 spanning the base of the container and able to rotate clockwise and anti-clockwise (e.g. through 90°) to obtain through-floor discharge of the contents of the container.

Typically, the elements 124 will be steel tubes or rolled hollow sections to which the fins have been welded. The optimum centre spacings of elements 124 will depend on the bridging properties of the material to be discharged but a centre spacing of around 150 mm would be typical. Although if the elements are of square or other non-circular cross-section, the fins may not be necessary for effective discharge to occur, the fins are nevertheless found to result in a more positive discharge and hence their presence is to be preferred. In the illustrated embodiment, the fins might project by about 25 mm, say, from the upper three corners of the square-section elements 124.

Rotation of the sections 124 in a to and fro motion is by an actuator device 126 in which a common linear actuator 130 is linked to the various sections by a series of crank arms. With relatively small containers or in small portions of a large unit, it will often be feasible to operate the linear actuator by hand without mechanical assistance.

As well as its uses in vermicomposting systems, apparatus according to the present invention could also find application in the discharge of materials such as municipal sludge or materials presenting severe bridging or other flow problems.

One such apparatus is shown in Figure 13 and consists of a hopper 140 with vertical sides and a floor 142 constructed of a steel grid or mesh. The optimum dimensions of the hopper are determined by the type of material to be fed.

Above the hopper 140 and in contact with the floor 142 is a framework 144 supporting a number of members 146 which span the width of the hopper.

Members 146 comprise breaker bars of any of the designs illustrated in the previous Figures and they serve to cause localised breakdown of the bridging effect by which the material rests on the floor 142. To achieve this end, the members 146 are caused to reciprocate slowly (say, 100 mm/sec) by, for example, a variable-speed electric screw type linear actuator 148. This

causes a controlled and even discharge over the whole hopper floor area and has the beneficial effect of breaking down lumps and structures within the material.

Below the floor 142 is mounted a simple light duty belt conveyor 150 to collect the discharge and transport it to a delivery point. This conveyor is lightly loaded and its speed is not critical as it does not serve as a metering device. Metering is done by the discharge floor 142 and flow rate is adjusted by the rate at which the linear actuator 148 reciprocates the breaker bar members 146.

In an alternative embodiment (not shown), the breaker bars form part of a motor-driven chain loop conveyor but this detracts from the simplicity and serviceability of a simple reciprocating breaker bar framework. In a further alternative, a rotary (e.g. propeller) breaker is driven by a high torque motor in a suitably proportioned cylindrical hopper having a perforated circular discharge floor.

Referring next to Figures 14 and 15, these show an underfloor scaper 160 for collecting waste 162 which has been forced through the apertured floor (not shown) of the container by the scaper bars to accumulate on collecting surface 164.

In essence, the scraper 160 comprises a frame 166 running in U-channel tracks 168, 169 and supporting a number of pivoted scraper blade assemblies 171 which lift on rearward movement of the frame 166 wherever they contact a pile of waste 162 on surface 164. In their forward movement, however, pivoting of the blade assemblies is prevented by contact between the lower surface of the frame 166 and abutment plates 173 mounted on the scapers. The structure of the hinges (174) is such that they will be unaffected by falling waste (see, e.g. Figure 15).

A double-acting hydraulic ram 175 with auto-shuttle valve, acts on one of the cross-members of the frame 166 to drive the frame in a reciprocatory motion under the container floor. During every forward stroke of this motion, the scraper assemblies are

held against rotation by the action of plates 173 and act to deliver waste in the direction shown by the arrow in Figure 14. During the reverse stroke, the blades are free to pivot and ride over the accumulated waste as shown in the dotted line position on the left of this Figure.

Referring lastly to Figure 16, this illustrates a breaker drive system comprising two pairs of double-acting rams 180, 181 arranged in opposition between ground anchors 183, 184 and transverse cross-bars 185, 186 of the breaker frame 188 so as to maintain the latter in tension at all times. It will be appreciated that the leading rams are extending with full piston-face forces.

The drive system of Figure 16 is intended principally as an alternative to the winched arrangements of the earlier Figures for containers up to 10 metres length, say, beyond which the power requiremens may become excessive. Typically, the breaker bars 190 are flat steel bars of 2.5 metres width and 40 x 12 mm cross-section. A typical ram stroke 191 and breaker bar centre-to-centre distance would be 2.5 metres and the steel mesh floor 192 of the container would typically have an aperture size of 75 x 75 mm, say.

Advantages of the drive system of Figure 16 are its simple lay-out and the absence of winches and cables in a corrossive waste environment.

CLAIMS

1. A discharge device comprising a container having an apertured floor, one or more material-displacing members engaging with or lying adjacent to the upper surface of the floor, and drive means for moving the one or more members bodily across the floor thereby to urge material in the container downwardly through the apertures in the floor.

2. A device as claimed in Claim 1 in which the container is square or rectangular when viewed in plan, and the one or more material-displacing members comprises an elongate member lying parallel to the length or width dimension of the container, the drive means being operative to move the elongate member in directions parallel to the other of these two dimensions.

3. A device as claimed in Claim 1 or Claim 2 in which the material-displacing member includes one or more vertical tines, each tine is apertured and the device includes aerating means for supplying air to these apertures.

4. A device as claimed in any preceding claim in which said elongate member comprises a first such member and the one or more material-displacing members includes a second elongate member arranged at right angles to the first member.

5. A device as claimed in any preceding claim in which the drive means comprises a winch or chain and sprocket system or one or more rams or other linear activators.

6. A vermicomposting system incorporating a discharge device according to any preceding claim.

7. A continuous vermicomposting apparatus as claimed in Claim 6 comprising a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of the charge, the discharge device being effective to remove from the bottom of the charge quantities of the material processed by the worms in the container.

8. An apparatus as claimed in Claim 7 in which the floor of the container comprises a plurality of longitudinally finned or otherwise

shaped bars of non-circular cross-section co-operating to provide a floor to the container and rotatable about their longitudinal axes to encourage material from the container to pass through the container floor.

9. An apparatus as claimed in any of Claims 6 to 8 including fan means operative to provide a flow of aerating and/or heating air to the undersurface of the charge.

10. An apparatus as claimed in any of Claims 6 to 9 including means for supplying supplementary heating to the middle and/or upper layers of the charge.

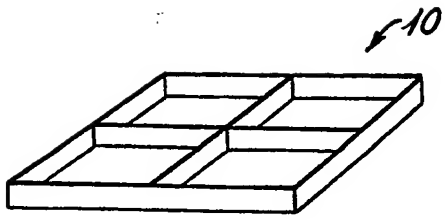

Fig. 1

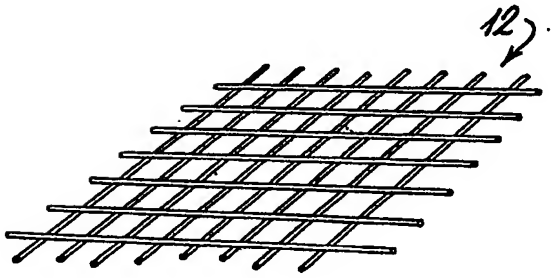

Fig. 2

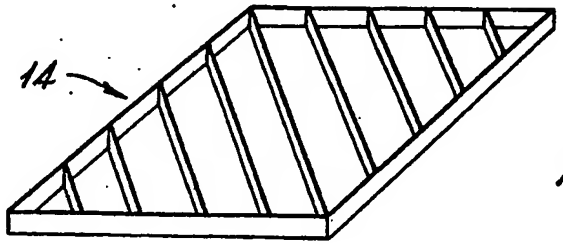

Fig. 3

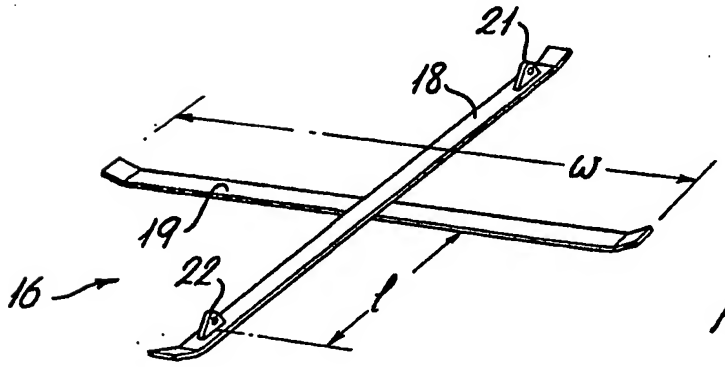

Fig. 4

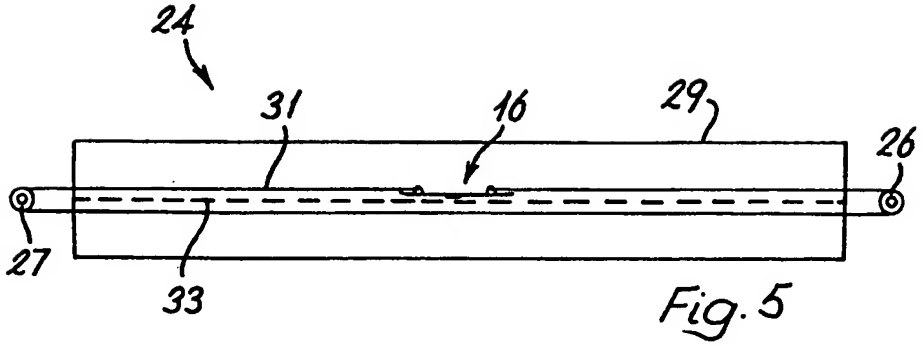

Fig. 5

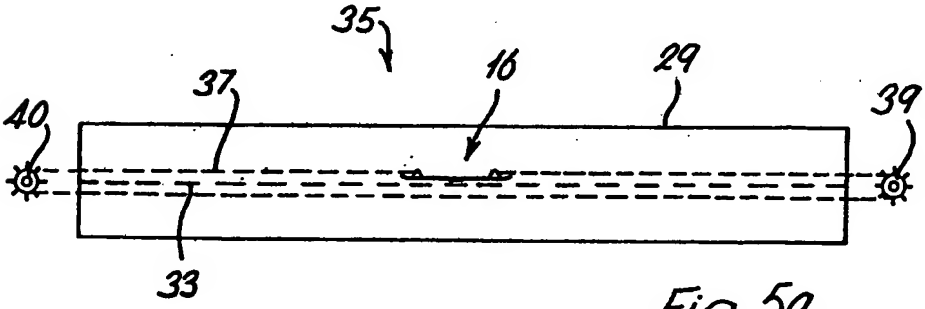

Fig. 5a

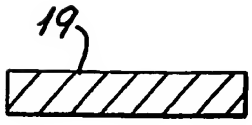

Fig. 6

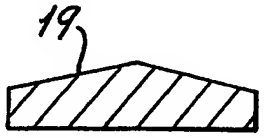

Fig. 6a

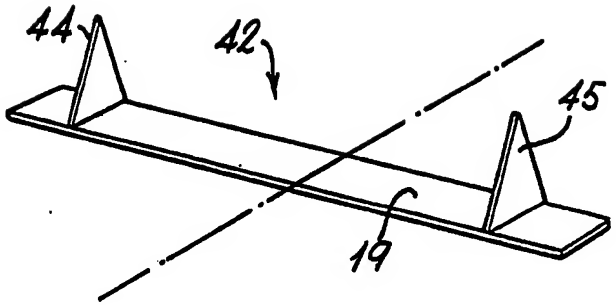

Fig. 7

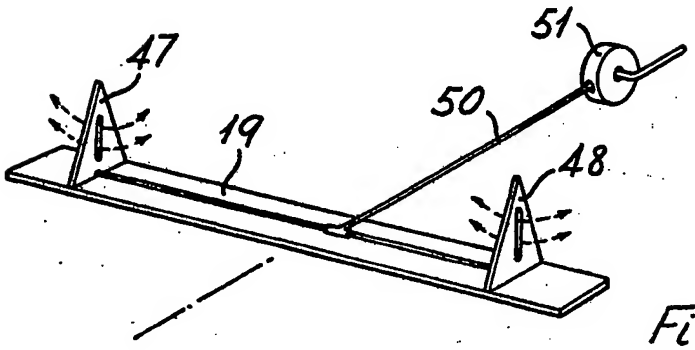

Fig. 8

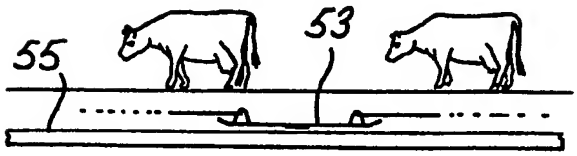

Fig. 9

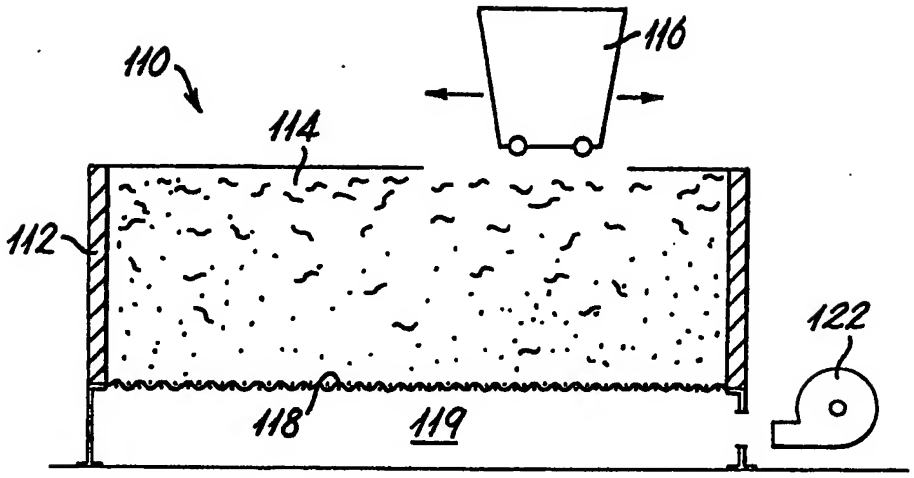

Fig. 10

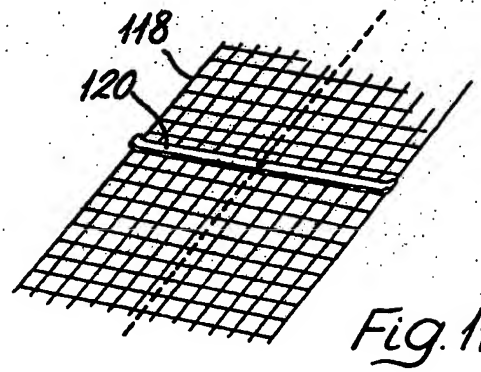

Fig. 11

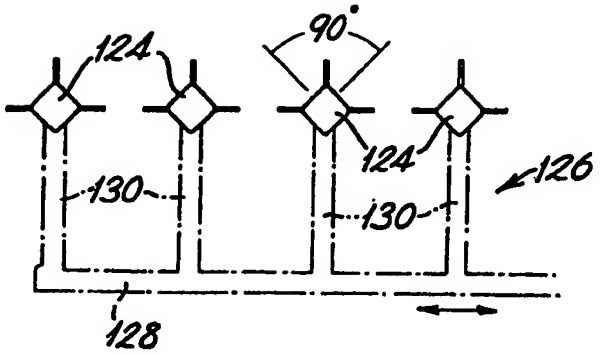

Fig. 12

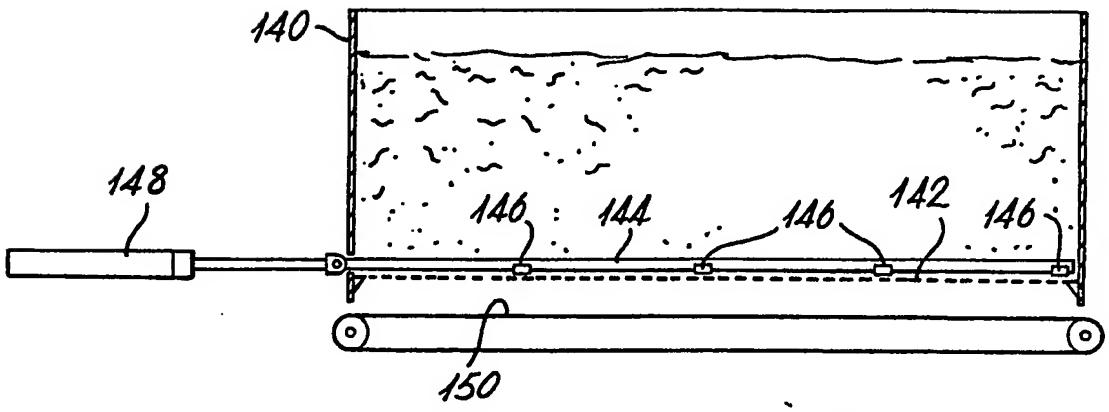

Fig. 13

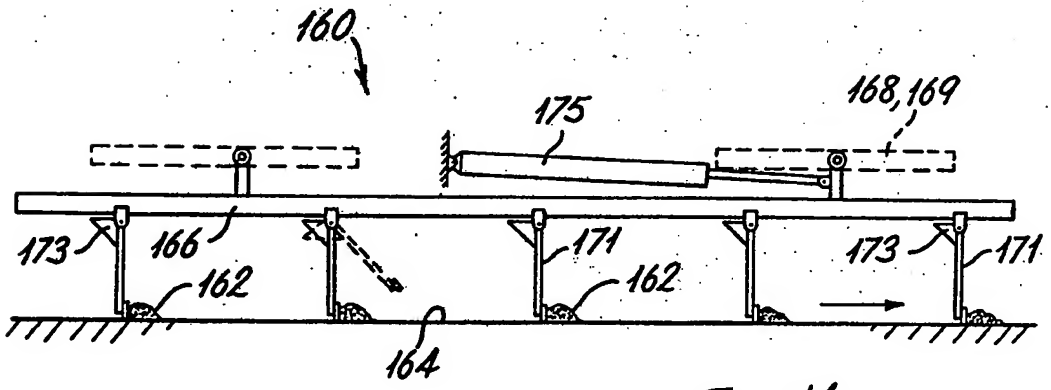

Fig. 14

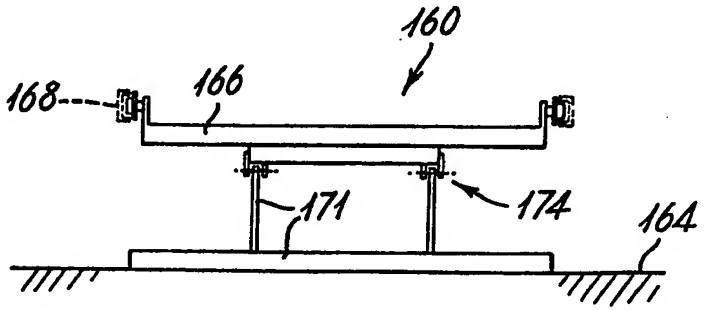

Fig. 15

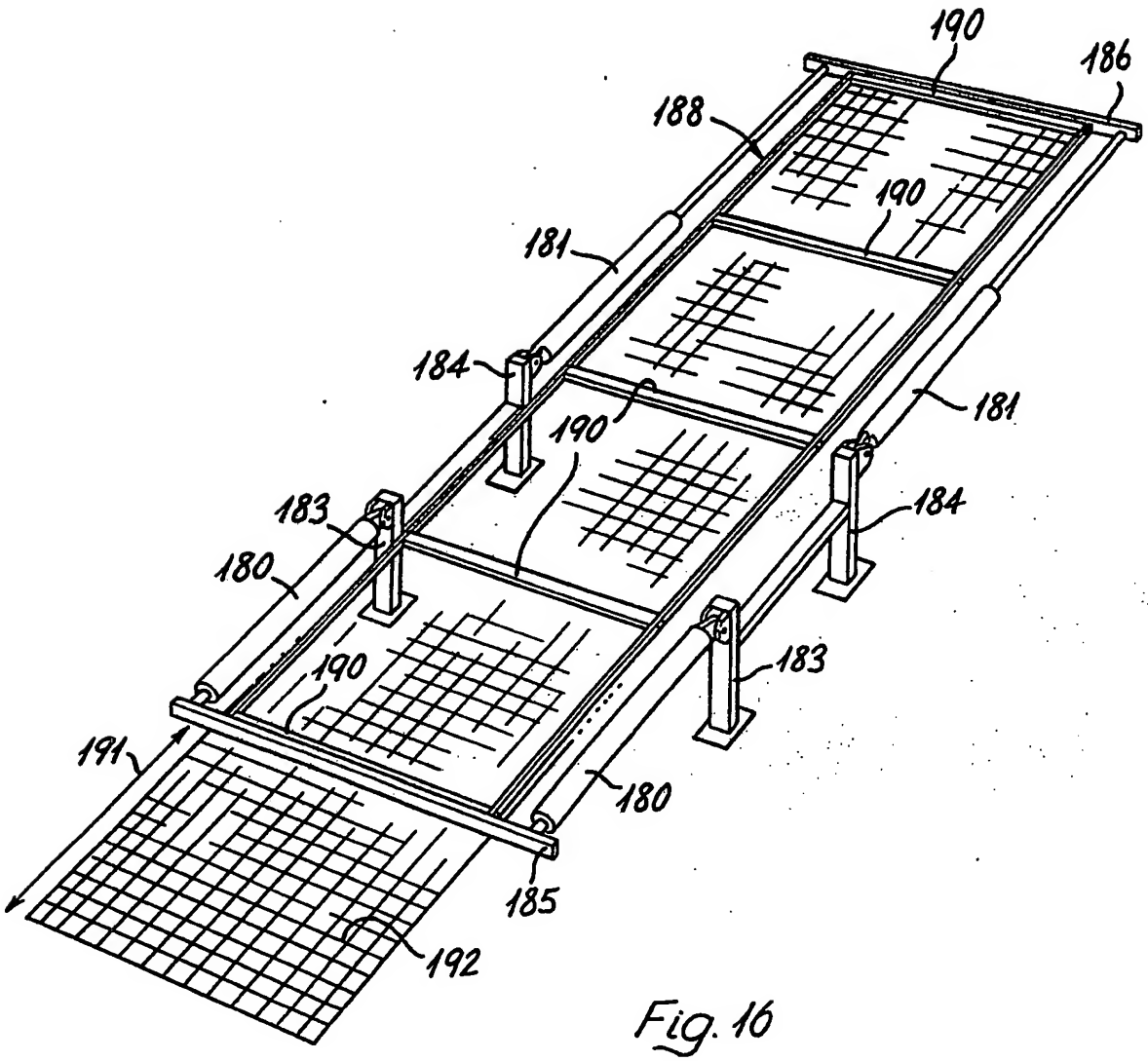
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Fig. 16

SN 10/531,241

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ABSTRACT

A worm reactor (10, 75) including a housing (11, 90) having a levelling means (28, 108) for maintaining a substantially uniform level of waste material (38, 91) within the housing (11, 90) as well as a discharge means (26, 95) for causing discharge of compost (40, 93) for ultimate collection.

The claims defining the invention are as follows:-

1. A worm reactor including a housing having a levelling means for maintaining a substantially uniform level of waste material within the housing as well as a discharge means for causing discharge of compost for ultimate collection.

2. A worm reactor as claimed in Claim 1 wherein the housing includes a top layer of waste material, an intermediate layer of worms and a bottom layer of compost.

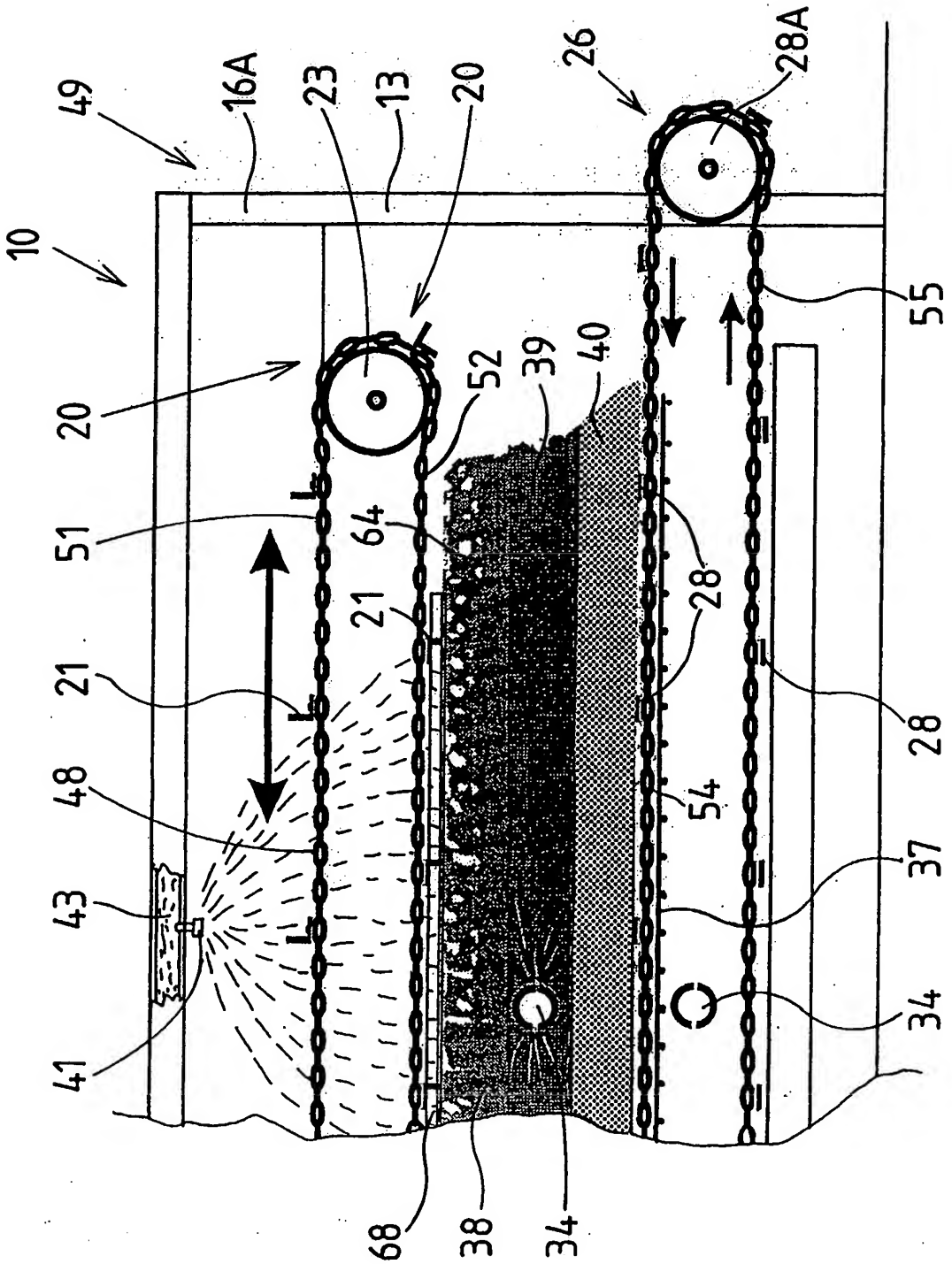
3. A worm reactor as claimed in Claim 2 wherein the levelling means comprises a transverse levelling bar which reciprocates along a top surface of the layer of waste material from end-to-end.

4. A worm reactor as claimed in Claim 2 wherein the levelling means comprises a plurality of levelling bars or cleats which travel along a top surface of the layer of waste material from end-to-end.

5. A worm reactor as claimed in Claim 4 wherein the levelling cleats are attached to a conveyor.

6. A worm reactor as claimed in any preceding claim wherein the levelling means is height adjustable to vary the distance or clearance between the levelling means and waste material in the housing.

7. A worm reactor as claimed in any one of Claims 1-5 wherein there is provided an auxiliary housing containing the levelling means which is located above the housing characterized in that the auxiliary housing is height adjustable to vary the clearance between the levelling means and waste material in the housing.


49
16A
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28A
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FIG. 5

P/00/008b 12/11/91
Section 29(1)
Regulation 3.1(2)

AUSTRALIA

Patents Act 1990

NOTICE OF ENTITLEMENT

We, MAPAS PTY. LTD., of 4 Harper Street, Mt. Gravatt, Queensland, 4122, Australia, being the Applicant in respect of the Application filed herewith, state the following:-

1. The person nominated for the grant of the patent has entitlement from the actual inventor by virtue of the entitlement of the Applicant, on the grant of a patent for the invention, to have the patent assigned to them.

2. The person nominated for the grant of the patent is the Applicant of the provisional application listed on the Patent Request form.

DATED this thirtieth day of November 1998.

Signed for and on behalf of the Applicant,
MAPAS PTY. LTD.,
by their Patent Attorneys,
FISHER ADAMS KELLY

.....
Robin Thomas KELLY - Registered Patent Attorney

P/00/011
Regulation 3.2

AUSTRALIA

Patents Act 1990

ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Invention Title: "WORM REACTORS"

The following statement is a full description of this invention, including the best method of performing it known to us:-

"WORM REACTORS"

THIS INVENTION relates to worm reactors for treatment of organic wastes.

Worldwide attention is now being increasingly focused on the prevention of environmental destruction of land, waterways, sea and atmosphere and, in this regard, most responsible governments are enforcing strict regulations on the disposal of waste materials. The greater proportion of these are solid and liquid organic waste.

Worms accelerate the decomposition of organic wastes threefold, concurrently converting waste to approximately half the original volume of clean healthy fertile castings and therefore worm reactors have previously been proposed in relation to treatment of organic wastes. Such reactors, which have been previously proposed, are ground beds open to the atmosphere.

Failure or less than anticipated performances of various worm reactors have principally been caused by:-

(i) lack of knowledge of the waste material;

(ii) poor or inappropriate design of the operating system that was employed;

(iii) lack of proper, or no control, of climatic conditions;

(iv) no control of vermin or pests;

(v) excessive land area required to process the designated volume of waste; and

(vi) poor management of worm beds.

There is a popular misconception that the problem of waste material disposed is solved by throwing a mass of worms into a heap of organic waste. This theory has resulted in a litany of failures and the consequent reluctance of some to appreciate the true potential of worms in efficient treatment of organic wastes.

Solid wastes contaminate land often by anaerobic decomposition which can continue for an indefinite period simultaneously polluting the atmosphere with greenhouse gases and contaminating land, waterways and oceans with soluble salts and heavy metals through ground, flood and surface water leaching. Some liquid waste such as liquid waste separated from agricultural wastes can be beneficially used for irrigation. This practice, however, is limited by the land area available as excessive irrigation causes run-off into waterways, rivers and eventually oceans resulting in damaging concentrations of salt, nitrogen and phosphorus in waterways and oceans.

Liquid wastes can be treated through filter beds containing worms in a casting habitat that forms part of the filter bed. In such filter beds, the excess of salts and heavy metals filtered out by the worms can be taken up by selective plants and trees, such as melaleucas and casuarinas for biological recycling.

Worldwide research carried out by highly reputable laboratories and institutions on worm feeding and breeding habits provides a wealth of information regarding worm performance in laboratory conditions. This research confirms that worms have an

important role to play in returning to the earth the discarded organic materials that have been harvested from it. It is therefore evident that there is a need for commercial exploitation of more efficient worm reactors for recycling organic wastes. Technology in the destruction of organic wastes by incineration, use of chemicals and other high energy means has outstripped any practical research in relation to worm reactors. The advantage of worm reactors is that they mass treat organic wastes to produce compost which may be recycled producing a valuable fertile product which is produced with minimal energy input.

Reference may also be made to an article by J.S. Price entitled *"Development of a Vermicomposting System"* on pages 294-300 of the Proceedings, Volume 1, of the 4th International CIEC Symposium, Agricultural Waste Management and Environmental Protection held on May 11-14, 1987 in Braunschweig, Germany. The editors were E. Welte and I. Szabolcs. The Price reference described a mechanized system for processing agricultural livestock wastes using the earthworm *Eisenia foetida*. The mechanized system included an elevated reactor wherein waste material was fed to the top of the reactor and compost was discharged at the bottom of the reactor wherein temperature was controlled by variation of the depth of waste between 200-500 mm in the reactor which gave a temperature range of between 20-25°C. Effective drainage and aeration was provided by a mesh floor of the reactor which prevented waterlogging and anaerobicity. The reactor comprised a frame which supported the mesh floor above the ground and compost material

was transferred through the mesh floor and the discharged compost was passed to one end of the reactor by a scraper. Raw waste material was applied mechanically in thin or 30 mm horizontal layers by a carriage which travelled on the top of the reactor which carriage reciprocated from end-to-end of the reactor. The reactor included an upper layer of waste material, an intermediate layer of worms and a bottom layer of compost material. The waste was scraped off the mesh floor of the reactor by a discharge mechanism which comprised a transverse breaker bar which reciprocated from one end of the mesh floor to the other end which set up a shear front causing a thin layer of compost material to be discharged. The breaker bar which was of cruciform shape facilitated efficient discharge of waste material while worm activity continued undisturbed above. The breaker bar could be reciprocated by winches at each end of the mesh floor or alternatively, a multi-breaker frame could be reciprocated by hydraulic cylinders.

However, in relation to the worm reactor described in the Price reference, it was considered that the method of distribution or feeding of waste material to the top of the reactor using the reciprocatable carriage was bulky and cumbersome as well as being time consuming and inefficient in operation. The use of a reciprocatable carriage was also expensive. It was also noted that the Price reference did not describe how the waste was passed from the carriage to the interior of the reactor.

It therefore is an object of the invention to provide a worm

reactor which may alleviate at least, to some extent, the aforementioned disadvantages of the prior art.

The worm reactor of the invention includes a housing having a levelling means for maintaining a substantially uniform level of waste material within the housing as well as a discharge means for causing discharge of compost for ultimate collection.

The housing may be of any suitable shape but is preferably cuboidal having a pair of opposed ends and opposed sides to provide a fully enclosed housing. To this end, the housing may also include a frame having a plurality of uprights as well as longitudinal frame members as well as transverse frame members. There may be provided a pair of opposed side panels as well as a pair of opposed end panels wherein each of the end panels and side panels may be hingedly attached to the frame.

Preferably the housing has a top section formed of two oblique panels or gables and, in this regard, the frame may include oblique frame members and a top frame member. Hatches or panels may be incorporated in the top section which may be pivoted outwardly to facilitate access to an interior of the frame for maintenance purposes.

The housing may include a top layer of organic waste, a middle or intermediate layer of worms and a bottom layer of compost material or "vermicompost" or "worm cast".

The levelling means maintains a top surface of waste material at a substantially uniform or planar level and may, for example,

include a transverse levelling bar which reciprocates along the top surface of waste material from end-to-end. The levelling bar may be operatively associated with suitable actuation means, such as a ram assembly which may be hydraulically actuated or pneumatically actuated as may be required. Alternatively, the levelling bar may be attached to chains, one of which is attached to an idler sprocket and the other of which is attached to a drive sprocket as shown in the aforementioned Price reference. Alternatively, a plurality of such levelling bars may be employed which travel along the top surface of the waste material from end-to-end.

However, more preferably there is provided a levelling conveyor which is provided with a plurality of transverse cleats which are located at spaced intervals along the conveyor. Preferably, the conveyor is provided with one or more suitably a pair of spaced chains or belts which support the plurality of cleats. Each of the chains or belts may be attached to a driving sprocket or pulley at one end and an idler sprocket or pulley at the other end. Each of the cleats may be rectangular or square in cross section or, more preferably, are L-shaped.

The levelling means may be height adjustable relative to an adjacent layer of waste material in the housing and this may be accomplished by making the levelling conveyor height adjustable as illustrated in one embodiment hereinafter. Alternatively, a top housing containing the levelling conveyor is made height adjustable relative to a bottom housing as described hereinafter in relation to another illustrated

embodiment by the use of pneumatically or hydraulically actuated ram assemblies.

The housing may also include a layer of mesh or perforated sheet which supports the bottom layer of compost referred to above.

The discharge means suitably comprises a bottom conveyor for transporting compost to a collection receptacle. There may also be provided harvesting means associated with the discharge means to harvest compost material from the housing into the discharge means.

In one form, such harvesting means may comprise a plurality of cleats which scrape or contact the bottom layer of compost to fall onto the conveyor through the mesh sheet described above whereinafter such conveyor may transport the compost to a receptacle adjacent the housing.

In another form, the housing means may comprise a scraper blade which, in one embodiment, reciprocates to and fro along the length of the mesh sheet. Such scraper blade may be actuated by a hydraulic ram assembly or pneumatic ram assembly or, alternatively, be attached to one or more conveyor chains or belts.

Alternatively, such harvesting means may comprise a plurality of valves which, in a closed position, form part of a bottom support sheet of the compost material and which may open when required by suitable control means to allow compost material to fall or be discharged onto the bottom conveyor. In one embodiment, there may be provided a plurality of rotors or pivotally mounted members having plates

attached thereto which form the abovementioned bottom support sheet but when each of the rotors are pivoted may cause upward or downward movement of the plates to provide discharge openings for the compost material.

Reference may be made to a preferred embodiment of the invention as shown in the attached drawings, wherein:-

FIG. 1 is an exploded perspective view of a worm reactor constructed in accordance with the invention;

FIG. 2 is a detailed view of the water sprayers located at a top location of the worm reactor shown in FIG. 1;

FIG. 3 is an end view of the worm reactor shown in FIG. 1;

FIG. 4 is a side view of the worm reactor shown in FIG. 1;

FIG. 5 is a detailed view of one end of the worm reactor shown in FIG. 4;

FIG. 6 is a plan view of the worm reactor shown in FIG. 1;

FIG. 7 is a detailed perspective view of support rails which support a bottom flight of the levelling conveyor;

FIG. 8 is a perspective view of another type of worm reactor constructed in accordance with the present invention;

FIG. 9 is a side view of the worm reactor shown in FIG. 8;

FIG. 10 is a view of one side of the worm reactor shown in FIG. 8 illustrating the drive means for the top and bottom conveyors;

FIG. 11 is a perspective view of a distribution member for use in the distribution means for feeding waste material into the top

conveyor; and

FIG. 12 is a perspective view of a rotor member for use with the harvesting means for harvesting worm cast onto the bottom conveyor.

In the drawings, there is shown worm reactor 10 which includes housing 11 which has a housing frame 12 having posts 13, longitudinal frame members 14A and 14B transverse frame members 15 and oblique frame members 16A interconnecting longitudinal frame member 14B and top frame member 16. The frame 11 may also include side panels 17 and end panels 18.

The worm reactor 10 also includes a feed hopper 19 for feeding waste material into housing 11. There is also provided an upper conveyor 20 which is provided with L-shaped cleats or scrapers 21 on chains 22 which are each attached to chain sprockets 23 located at each end of housing 11 as shown in FIG. 1. There is also provided an axle or shaft 24 interconnecting each chain sprocket 23. As is also shown in FIG. 1, upper conveyor 20 also includes a drive sprocket 25 which is connected to an appropriate drive means such as an output shaft of a motor (not shown). There may also be provided a reduction gear box (not shown) intermediate the drive motor and the drive sprocket. There is also included a lower conveyor 26 of similar structure to upper conveyor 20 which is provided with opposed chains 27 interconnected by cleats 28. Conveyor 26 is also provided with chain sprockets 28A interconnected by axle 26A as well as a drive sprocket 29 and bearings 30 as shown in FIG. 1. Similar bearings 30A are used in upper conveyor 20.

There is also provided hatches or covers 31 which are mounted within each of the apertures 32 of frame 12 which are bounded by frame members 14B, 16 and 16A or end panel 18 as shown in FIG. 1. In FIG. 1, only one hatch 31 is shown for the sake of convenience. There is also shown a network 33 of transverse pipes 34 having apertures or jets 35 which are interconnected by longitudinal pipes 36 to provide a continuous circulation of air within housing 11 which may be emitted from jets 35. Each of transverse pipes 34 may extend through holes 37A located in side panels 17. There is also provided elbow joints 35A and T joints 35B for screw-threadedly connecting pipes 35 and 36. There is also provided a mesh sheet 37 located within housing 11. The housing 11 also contains a top layer 38 of waste material, an intermediate layer 39 of worms through which may extend pipes 34, and a bottom layer 40 of worm castings. There is also provided a plurality of nozzles 41 located at spaced intervals along top frame member 16.

In FIG. 2, there is shown an individual nozzle 41 which provides a spray of water 42, which nozzle is connected to water conduit 43 for conveying water under pressure to nozzles 41. Water conduit 43 is suitably a hollow interior of top frame member 16. There is also shown hinges 44 which interconnect each of hatches 31 to frame member 16 so that hatches 31 may be pivoted upwardly as required for inspection or maintenance purposes as well as handles 44A.

In FIG. 3, there is shown a bottom layer of worm castings 45 which is collected in housing 11 after passage through mesh sheet 37 by

the action of lower conveyor 26 as hereinafter described. Layer 45 is collected on collector tray 46.

In FIGS. 4-5, there is shown housing 11 in side view wherein waste material is deposited on feed hopper 19 which includes an entrance portion 19A together with a guide portion 19B whereby waste material is guided to fall between each of the spaces 48 located between cleats 21 of upper conveyor 20 and thus form the top layer 38 which is supported by mesh sheet 37.

In FIG. 5, there is shown a more detailed view of one end 49 of housing 11 remote from feed hopper. In FIG. 5, there is shown guide 50 and top flight 51 of upper conveyor 20 which has a lower flight 52. There is also provided a lower guide 53 for supporting top flight 54 of lower conveyor 26 which also has a lower flight 55.

It will also be appreciated that when cleats 28 on top flight 54 are in the position shown in FIG. 4 that they may harvest or scrape castings from the top surface 63 of mesh sheet 37 into collection tray 46. It will also be noted that cleats 21 on lower flight 52 of conveyor 20 scrape the top surface 64 of waste material 38 to ensure that top surface 64 is substantially level.

FIG. 6 shows a plan view of reactor 10 wherein only four hatches 31 are shown for convenience with the remainder of such hatches having been omitted for convenience. It will also be appreciated that the reactor 10 has an axis of bilateral symmetry.

FIG. 7 also shows a detailed view of support rails 68 which

are L-shaped in cross section as shown for supporting lower flight 52 of top conveyor 20. Such rails 68 are height adjustable and this is shown by adjustment belts 72 engaging in slots 69 in side panels 17 with the use of washers 70 and nuts 71.

In FIG. 8, there is shown a modified worm reactor 75 that incorporates a feed hopper 76 having a cover 77 wherein waste material 78 is fed into hopper 76 wherein the waste is subjected to the action of feed rollers 79 which function not only in forcing the waste material into a top or auxiliary housing 80 which contains top conveyor 81, best shown in FIG. 9, but also breaking up the waste material into smaller particles.

The feed rollers 79 are driven by gears 82 which mesh together as shown in FIG. 8. It will be appreciated that gears 82 may be driven by any suitable form of drive means such as an electric motor (not shown).

The worm reactor 75 also includes a control panel 83 mounted to control box 84. The conveyor housing 80 also has covers 85 and also may be provided with strengthening ribs 86. The top conveyor 81 has a drive shaft 88 and is supported on hydraulic or pneumatic ram assemblies 89 for the purpose of controlling the height of top conveyor 87 above a bottom housing 90 which contains a top layer of waste material 91, an intermediate layer of worms 92 and a bottom layer of worm cast 93 as best shown in FIG. 9.

There is also provided opposed support frames 94 which also house a bottom conveyor 95 which is preferably formed from mesh

material. Bottom conveyor 95 is provided with drive roller 95A. Also indicated is control mechanism 94A for harvesting members 96 best shown in FIG. 9. Harvesting members 96 harvest worm cast from level 93 onto bottom conveyor 95 as best shown in FIG. 9. Also shown is an air manifold 97 connected to a source of pressurized air (not shown) for aerating a top flight 98 of bottom conveyor 95. Connected to air manifold 97 are supply conduits 99. Also shown at each end of reactor 75 are water tanks 100 each having a water inlet 101 and cap 102 for replenishing each tank 100 when required.

As best shown in FIG. 9, the action of feed rollers 79 is shown in forcing waste material 78 into top housing 80 through chute 103. There is also provided water sprays or jets 104 each connected to a common manifold 105 for moistening the top bed or layer 91 of waste material when required. Elevation of top housing 80 by pistons 89A is indicated by the double headed arrow in full outline. Pistons 89A are supported in cylinders 89B bolted to frames 94 at 106. Also shown is inlet 107 for fluid for entering cylinders 105 when required.

The top conveyor 81 is provided with cleats 108 for levelling the top layer 91 of waste material in similar manner as described in the first embodiment shown in FIGS. 1-8.

There is also provided harvesting members or rotors 96 for harvesting worm cast from layer 93 onto bottom conveyor 95 and, as such, cleats 28 are replaced by harvesting rotors 96. As shown in FIG. 12, each rotor is star-shaped in cross section having a plurality of plates

110 and opposed ends comprising pipes 111. Each rotor 96 is connected to one end of an associated link 112. Each link 112 is attached at its other end to a control rod 113 so that upon linear or reciprocatable movement of threaded control rod 113, each link will pivot from an upright position as shown in FIG. 10 to an oblique position as shown in FIG. 9. To facilitate this, each link 112 also includes an actuating block 112A engageable in an associated slot 112B. Also, each link 112 has an aperture 112C for engaging an associated pipe 111.

FIG. 10 illustrates an open position for each rotor 96 which allows worm cast or compost 93 to fall through spaces or gaps 115 onto the top flight 98 of conveyor 95 as shown. On the other hand, FIG. 9 illustrates a closed position for each rotor 96.

It will also be appreciated that links 112 when in either an oblique position shown in full outline in FIG. 9 or another oblique position as shown in phantom in FIG. 9 will retain each rotor in a closed position. Thus, a full cycle will comprise movement of each link 112 from a closed position as shown in FIG. 9 to an open position having either oblique position as shown in FIG. 10 and back to the original upright position shown in FIG. 9.

When worm cast 93 has been deposited upon flight 98 of conveyor 95, such cast may then be deposited into collection receptacle 116 as shown in FIG. 10. Movement of the conveyor 95 is also shown by the arrows in full outline. There is also provided air supply conduits 99 which directs a flow of air upwardly onto the cast supported on flight 98 of

conveyor 95. There is also provided air conduits 117 shown in phantom for aeration of worms 92.

In FIG. 11, there is shown the drive means 118 for each conveyor 81 and 95 and such drive means includes a drive motor 119 mounted on mounting frame 120 and gear box 121 which is coupled to drive pulley 122. The drive pulley 122 is coupled to another pulley 123 attached to drive shaft 114 of bottom conveyor 95. There is also provided belt clutch 124.

There is also provided belt 125 attached to drive pulley 122 which also engages with pulley 126 coupled to drive shaft 88 of top conveyor 81, pulley 128 and pulley 129. Each of pulleys 128 and 129 are attached to control lever 130 which is provided with counterweight 131 at its other end as shown. Pulley 128 is also attached to housing 80 while pulley 129 is only attached to control lever 130. This enables control lever 130 to pivot from a position shown in full outline to a position shown in phantom and thus the assembly of lever 130 and counterweight 131 together with pulleys 128 and 129 functions as a suitable belt tensioner to belt 125.

In FIG. 12, the feed rollers 79 are illustrated in more detail comprising star-shaped gear 82, axle 132 and tines 133 oriented at different angles to the longitudinal axis of axle 132 as shown to facilitate breaking up of waste material and also forcing the waste material down chute ...

The rotors 96 are also illustrated in greater detail comprising

opposed end conduits 111 and plates 110.

It is also believed that the worm reactor of the invention will provide an inexpensive and efficient method of disposal of organic waste which, at present, can only be disposed of by methods which are not environmentally acceptable, such as incineration and chemical means described above or by landfill.

Another advantage of the worm reactor of the invention is that it enables organic waste to be disposed of at the source of such waste and thus waste which emanates from restaurants, hotels, shopping centres and institutions does not require to be transported to an incinerator or landfill site.

It will also be appreciated that, in the near future, waste from abattoirs, dairy farms, piggeries will have to be disposed of by methods which are far more environmentally friendly than the present methods as described above and thus the worm reactor of the invention will become an increasingly commercial proposition. Such worm reactors can dispose of organic wastes with minimal labour.

The organic wastes which are subject to treatment by the worm reactor of the invention include:-

(1) domestic and kitchen waste from small scale operations;

(2) agriculture and abattoir waste; and

(3) the filtrate of waste liquids.

It is therefore considered that the worm reactor of the

invention will provide a ready solution to efficient disposal of the waste referred to above and, in particular, domestic and kitchen waste because, at present, this waste is extremely variable in nature and subject to fly and vermin infestation which occurs in areas of high population and human habitation.

The worm reactor of the invention is not only vermin pest free but can operate with minimum unskilled labour.

In the worm reactor of the invention, the waste is totally enclosed and operates in a controlled artificial climate, thereby enabling the worms to work at optimum capacity 24 hours a day. The worm reactor of the invention may also incorporate a milling/grinding mixing operation at the feed end of the reactor. It is anticipated that these reactors will be located close to habitation and therefore will be completely odourless.

The worm reactor of the invention can also provide appropriate control of such variables as temperature, oxygen content, moisture content, pH, aeration and humidity to facilitate the best conditions for propagation of the worms which may be automatically adjusted as may be required by automatic sensors. In this regard, the aeration pipes 34 and 117 may not only provide the worms in levels 39 and 92 with oxygen but also heated air if the worm reactor is located in a cold climate.

It will also be appreciated that the bottom layer of pipes 34 underneath layer 40 are used for drying the worm castings collected in layer 45 in the FIGS. 1-7 embodiment.

The claims defining the invention are as follows:-

1. A worm reactor including a housing having a levelling means for maintaining a substantially uniform level of waste material within the housing as well as a discharge means for causing discharge of compost for ultimate collection.

2. A worm reactor as claimed in Claim 1 wherein the housing includes a top layer of waste material, an intermediate layer of worms and a bottom layer of compost.

3. A worm reactor as claimed in Claim 2 wherein the levelling means comprises a transverse levelling bar which reciprocates along a top surface of the layer of waste material from end-to-end.

4. A worm reactor as claimed in Claim 2 wherein the levelling means comprises a plurality of levelling bars or cleats which travel along a top surface of the layer of waste material from end-to-end.

5. A worm reactor as claimed in Claim 4 wherein the levelling cleats are attached to a conveyor.

6. A worm reactor as claimed in any preceding claim wherein the levelling means is height adjustable to vary the distance or clearance between the levelling means and waste material in the housing.

7. A worm reactor as claimed in any one of Claims 1-5 wherein there is provided an auxiliary housing containing the levelling means which is located above the housing characterized in that the auxiliary housing is height adjustable to vary the clearance between the levelling means and waste material in the housing.

8. A worm reactor as claimed in Claim 7 wherein there is provided hydraulic or pneumatic ram assemblies between the auxiliary housing and the housing containing the waste material.

9. A worm reactor as claimed in any one of Claims 2-9 wherein there is provided harvesting means for harvesting compost material from the housing into the discharge means.

10. A worm reactor as claimed in Claim 9 wherein the harvesting means comprises one or more transverse cleats which move from one end of the housing to the other and which scrape or harvest compost from the housing into the discharge means.

11. A worm reactor as claimed in Claim 10 wherein the compost is suspended on a mesh or perforate sheet which is contacted by the transverse cleat(s).

12. A worm reactor as claimed in Claim 10 or 11 wherein the transverse cleats are attached to a bottom conveyor which transports compost to a collection receptacle.

13. A worm reactor as claimed in Claim 9 wherein the harvesting means comprises a plurality of valves in the form of pivot members which, in the closed position, form a bottom sheet of the housing and, in the open position, provide a plurality of openings for transfer of compost into the discharge means.

14. A worm reactor as claimed in Claim 13 wherein the pivot members are each controlled by a control rod which moves in a reciprocatable manner.

15. A worm reactor as claimed in Claim 14 wherein each pivot member is pivotally attached to an associated link which is pivotally attached to the control rod.

16. A worm reactor as claimed in any one of Claims 1-11 and 13-15 wherein the discharge means is a bottom conveyor which transports compost from the housing to a colloidal receptacle.

17. A worm reactor as claimed in Claim 16 wherein the bottom conveyor is provided with aeration means for aerating compost located on an upper flight of the bottom conveyor.

18. A worm reactor as claimed in any one of Claims 2-17 wherein the housing is provided with aeration means to aerate a layer of worms in the housing.

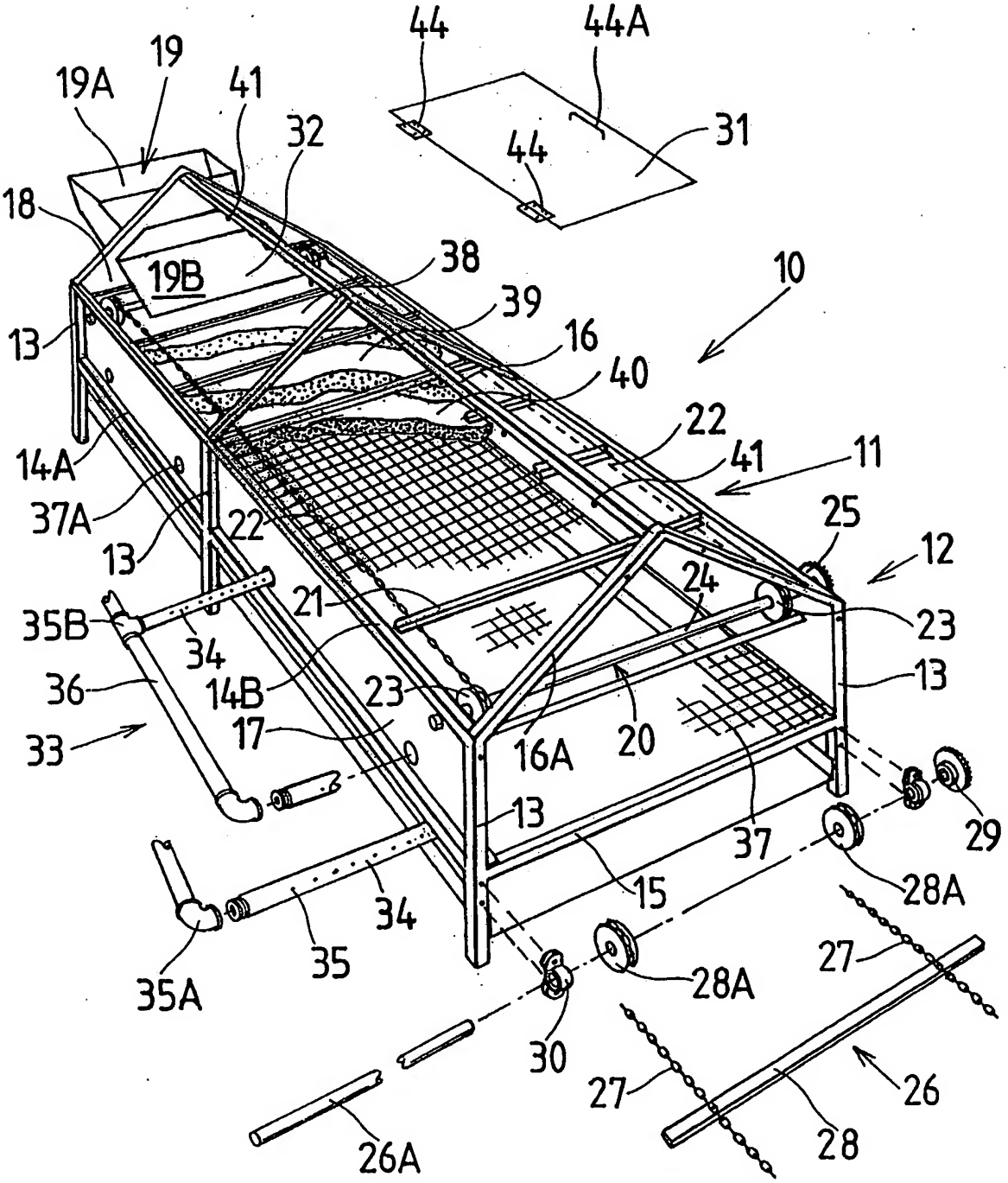
19. A worm reactor substantially as herein described with reference to the accompanying drawings.

DATED this thirtieth day of November 1998.

~~MAPAS PTY. LTD.~~ Marketing & Purchasing Advisory Service Pty. Ltd.

by their Patent Attorneys,

FISHER ADAMS KELLY.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37A
22
25
13
12
24
21
23
35B
34
36
14B
23
13
17
16A
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35A
28A
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26A
28

FIG. 1

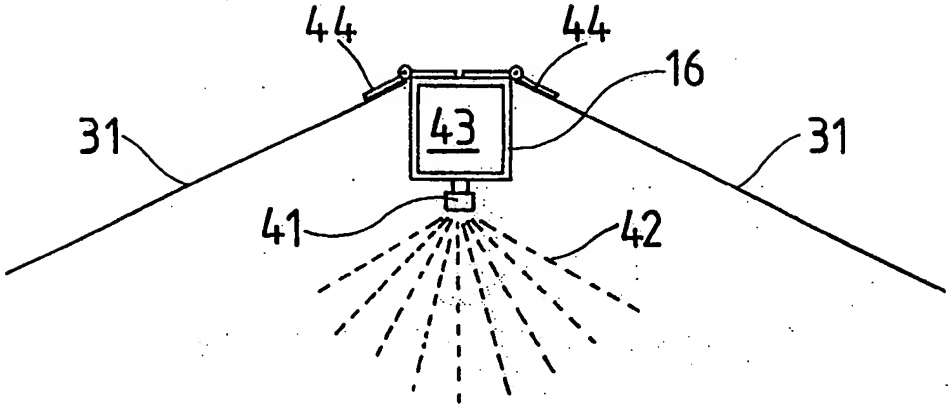
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FIG. 2

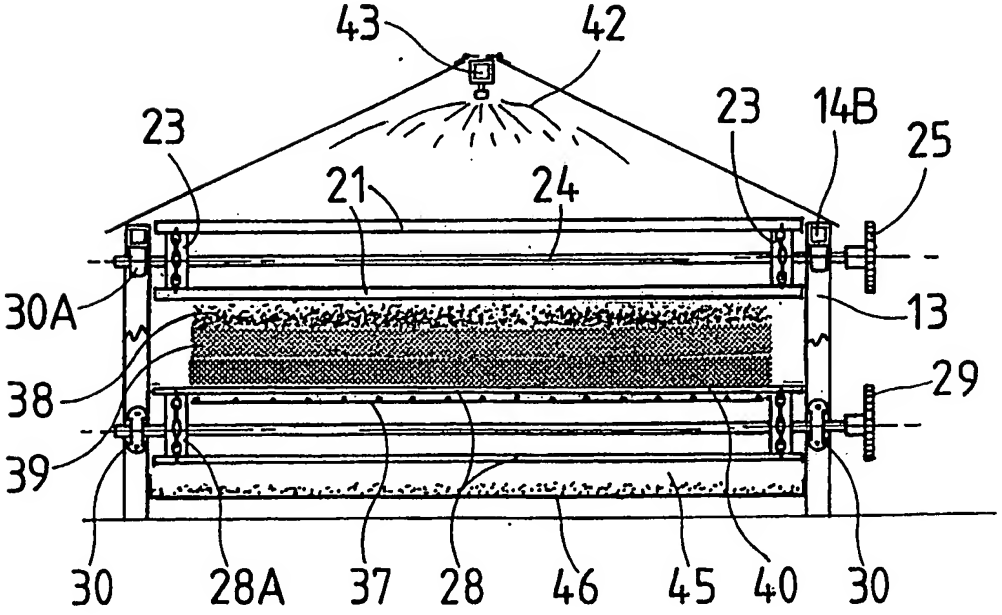
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FIG. 3

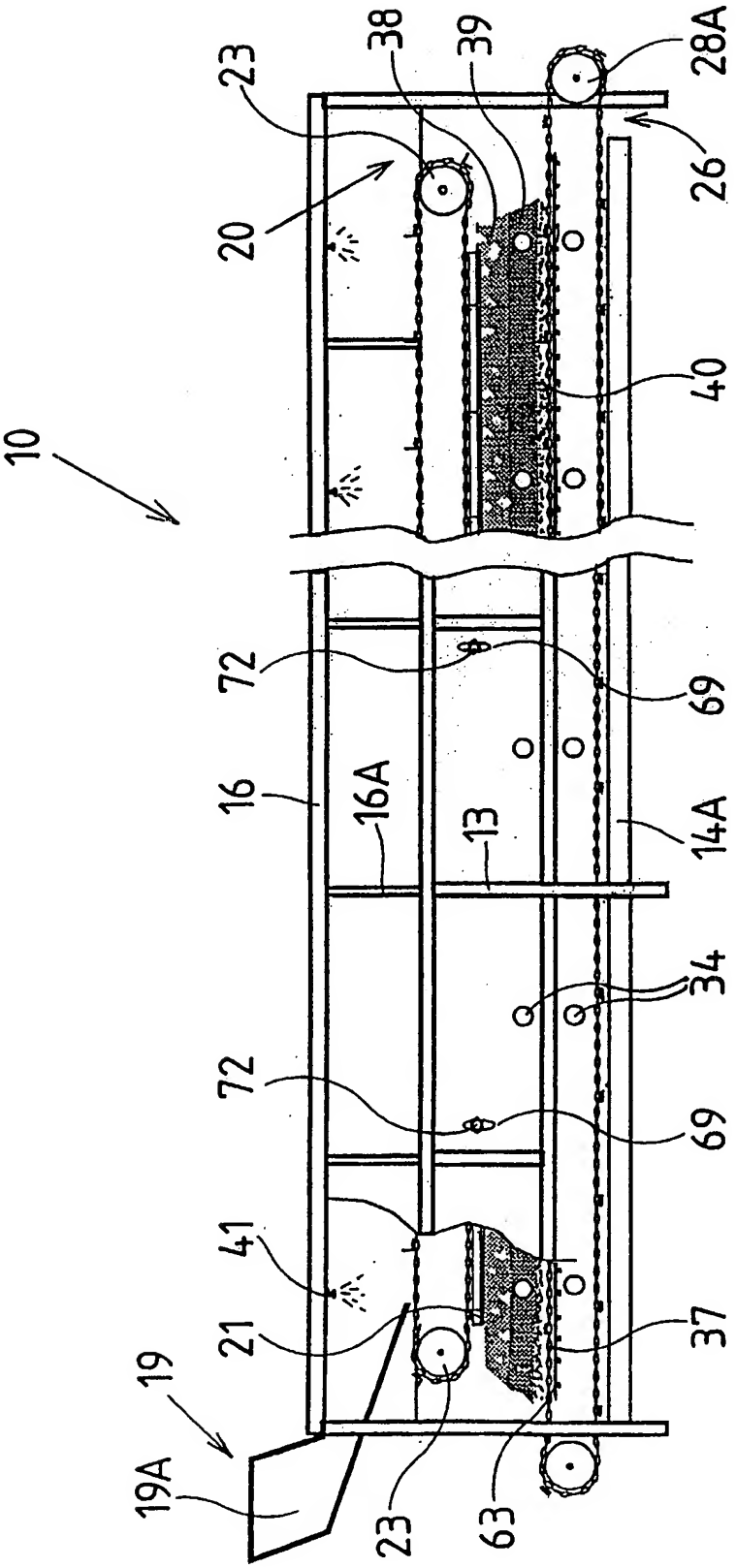
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FIG. 4

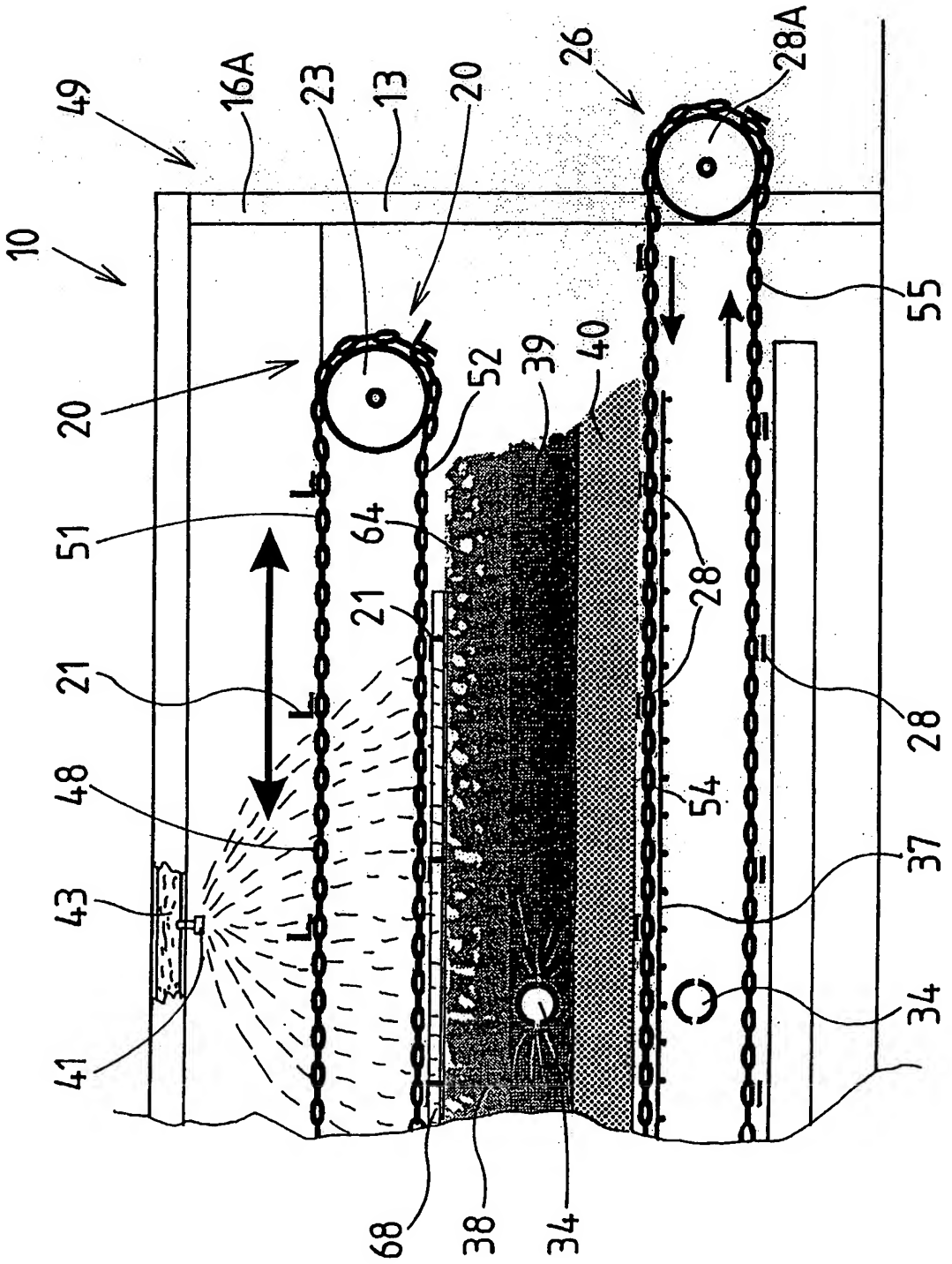
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FIG. 5

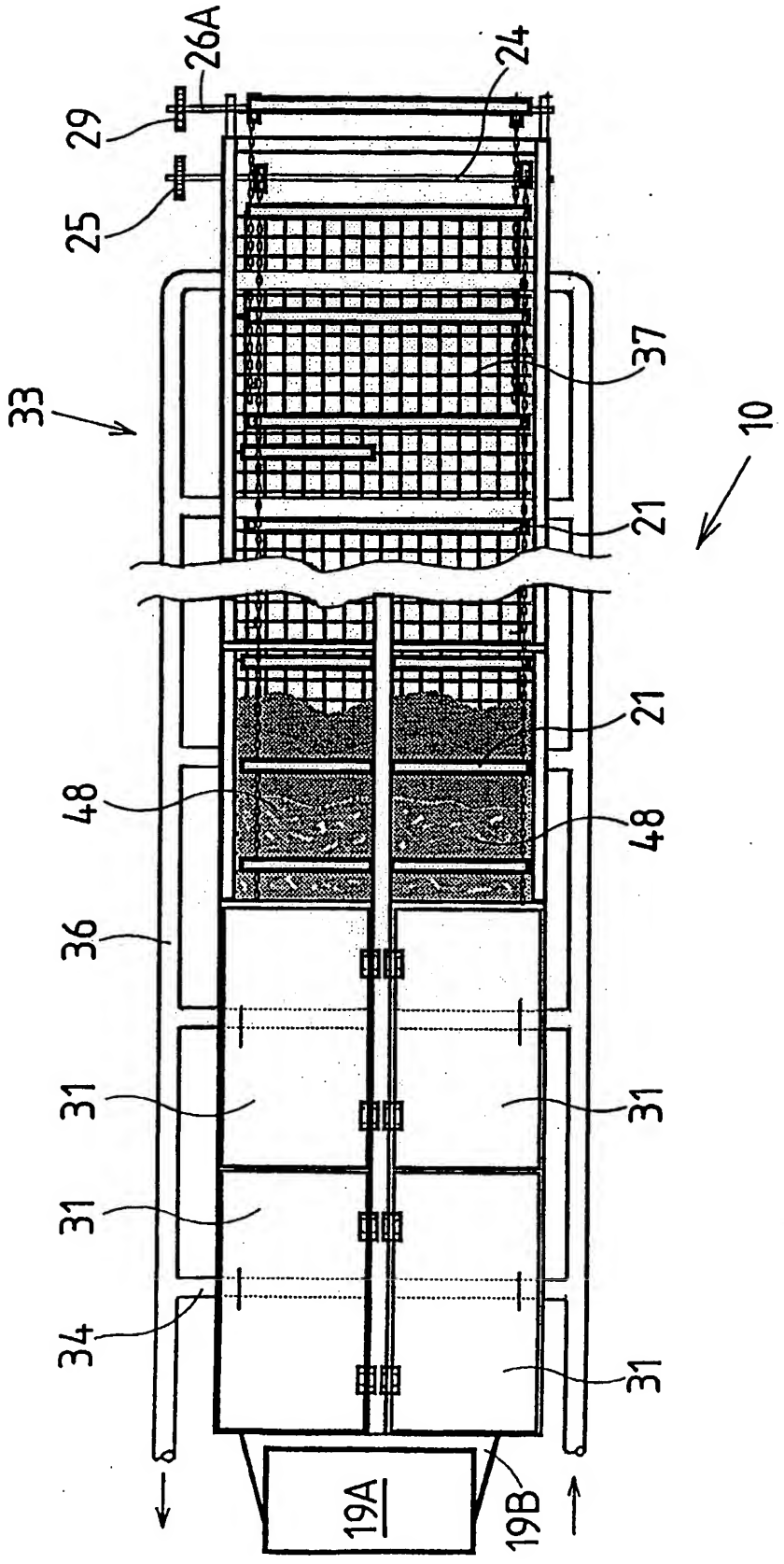


FIG. 6

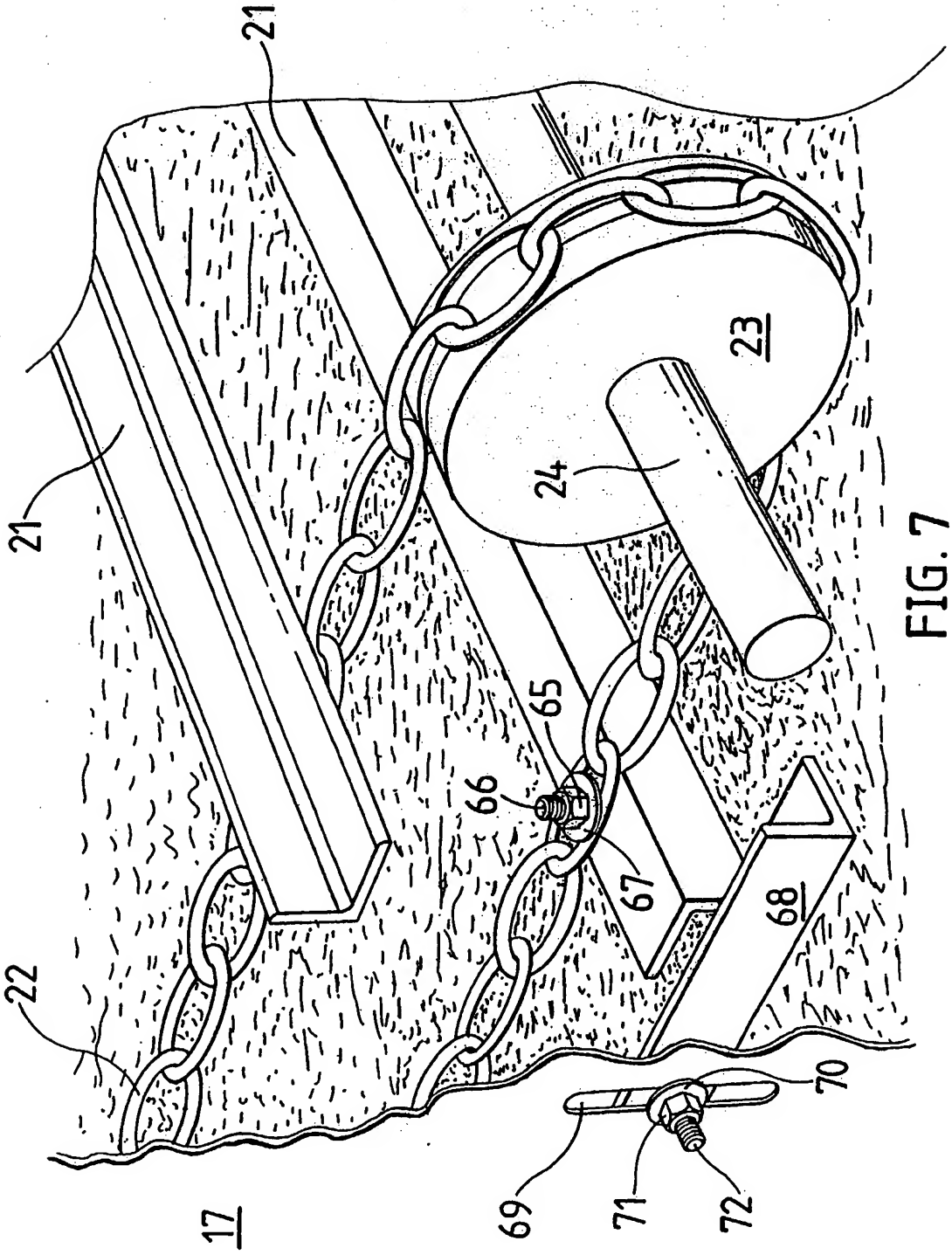
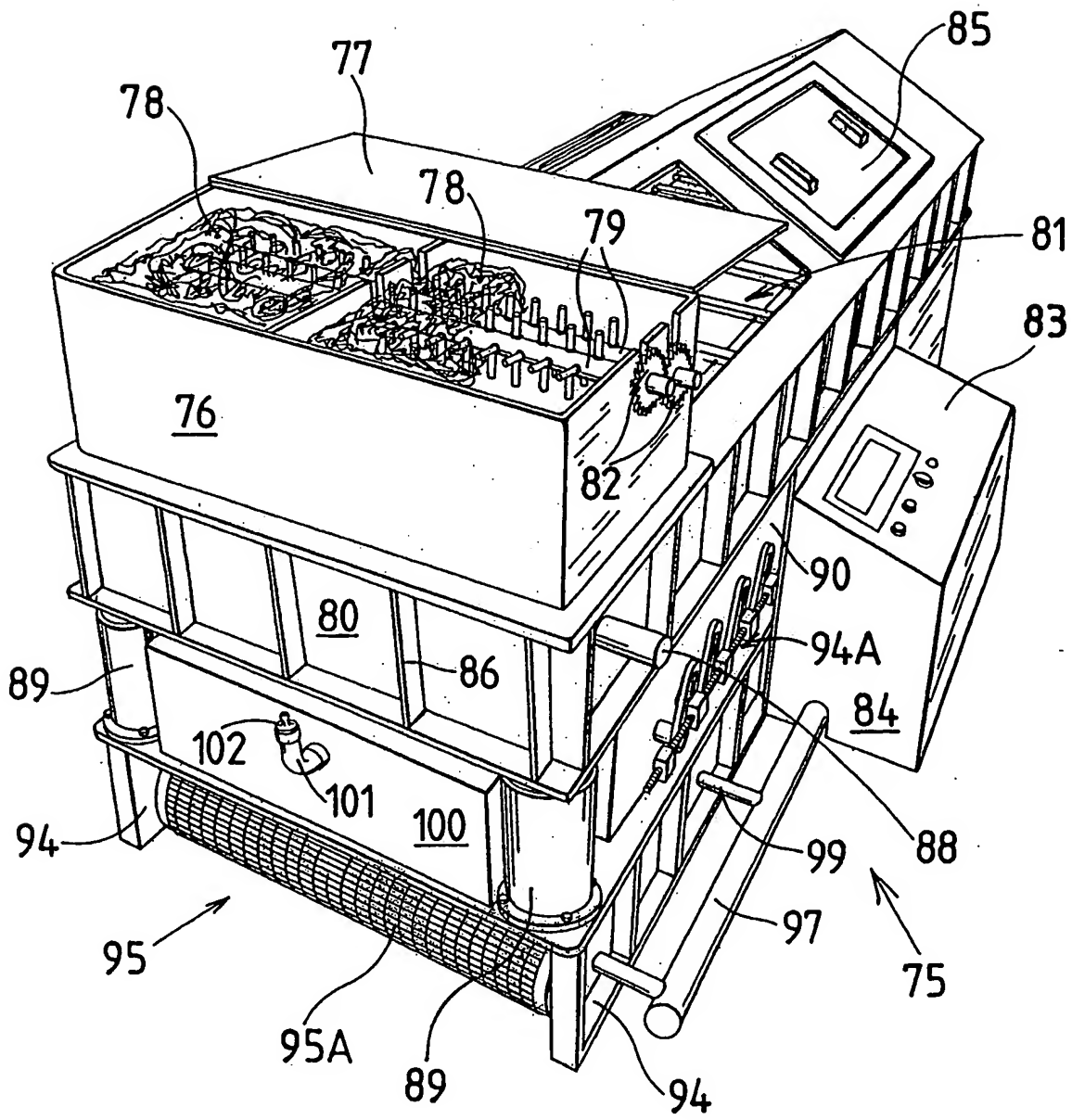


FIG. 7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95A
89
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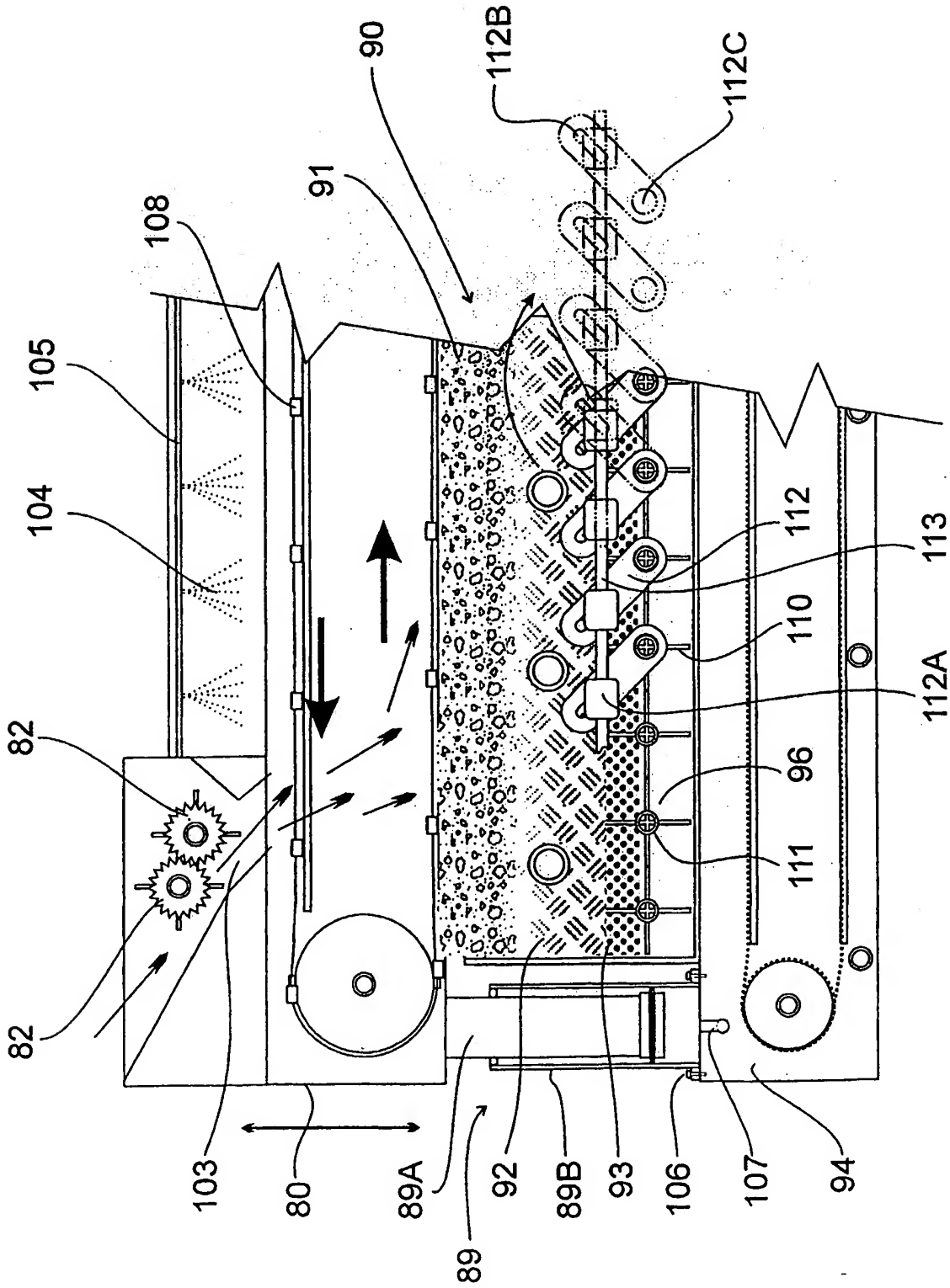
FIG. 8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107
94
89

FIG. 9

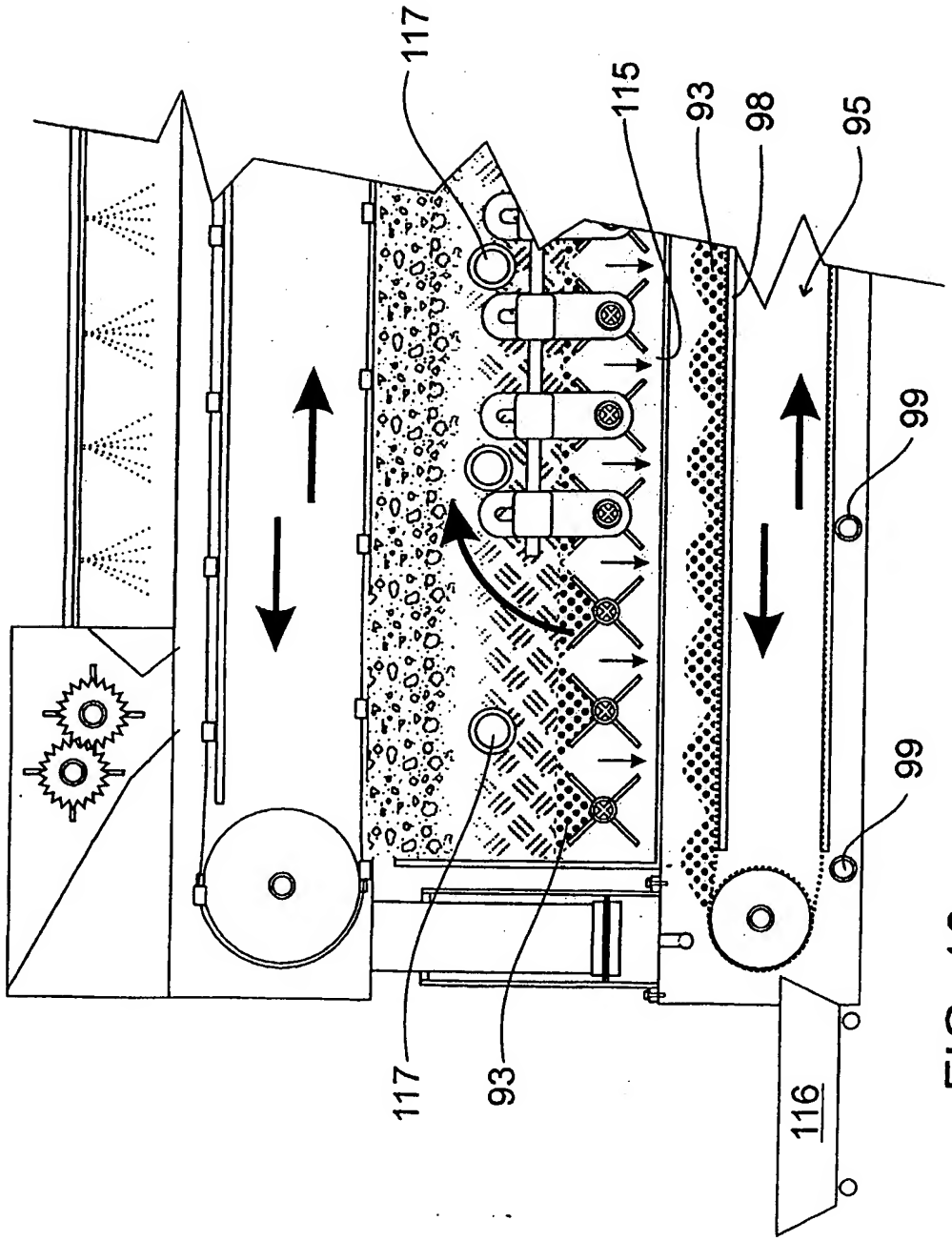

FIG. 10

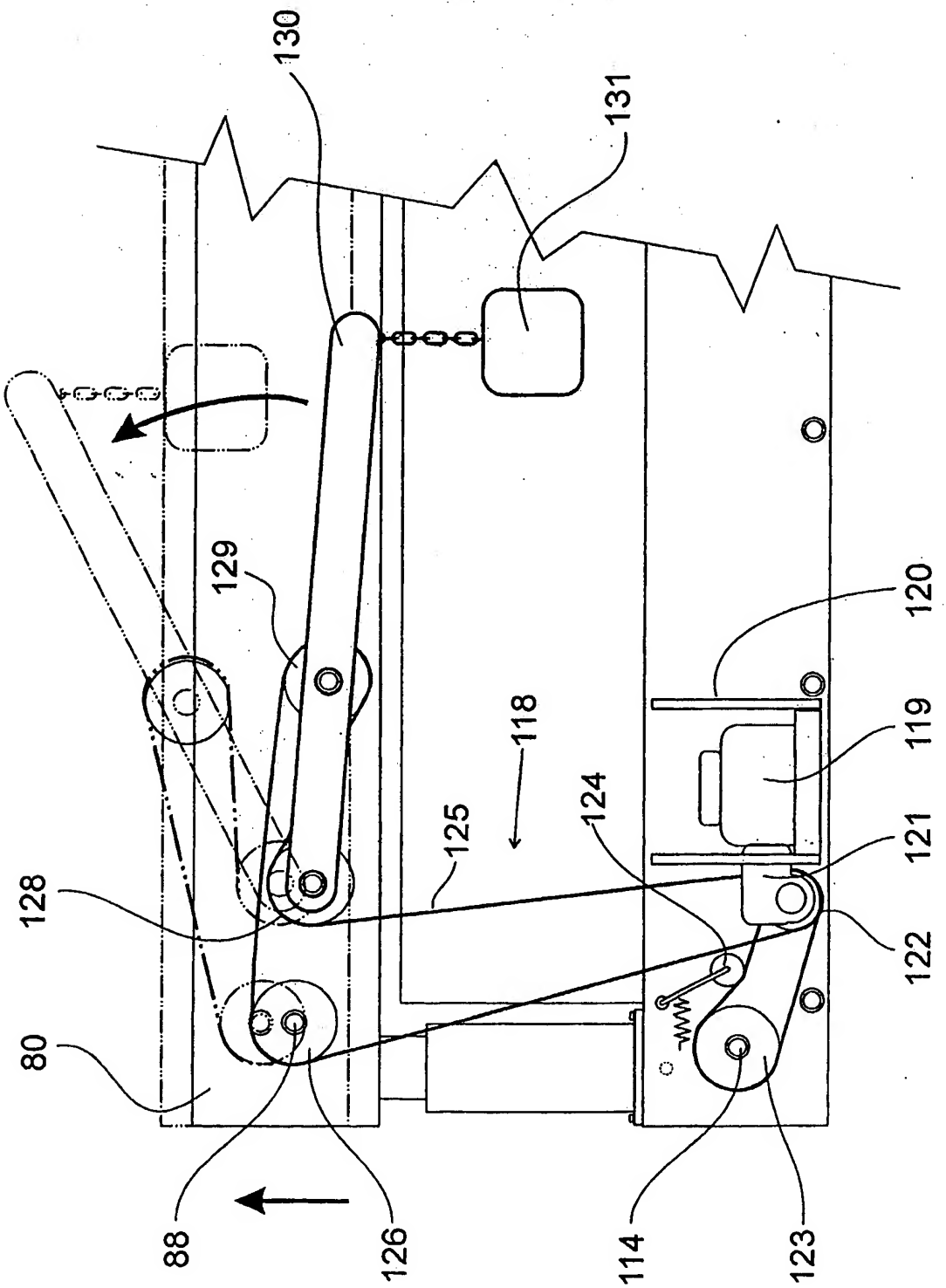

FIG. 11

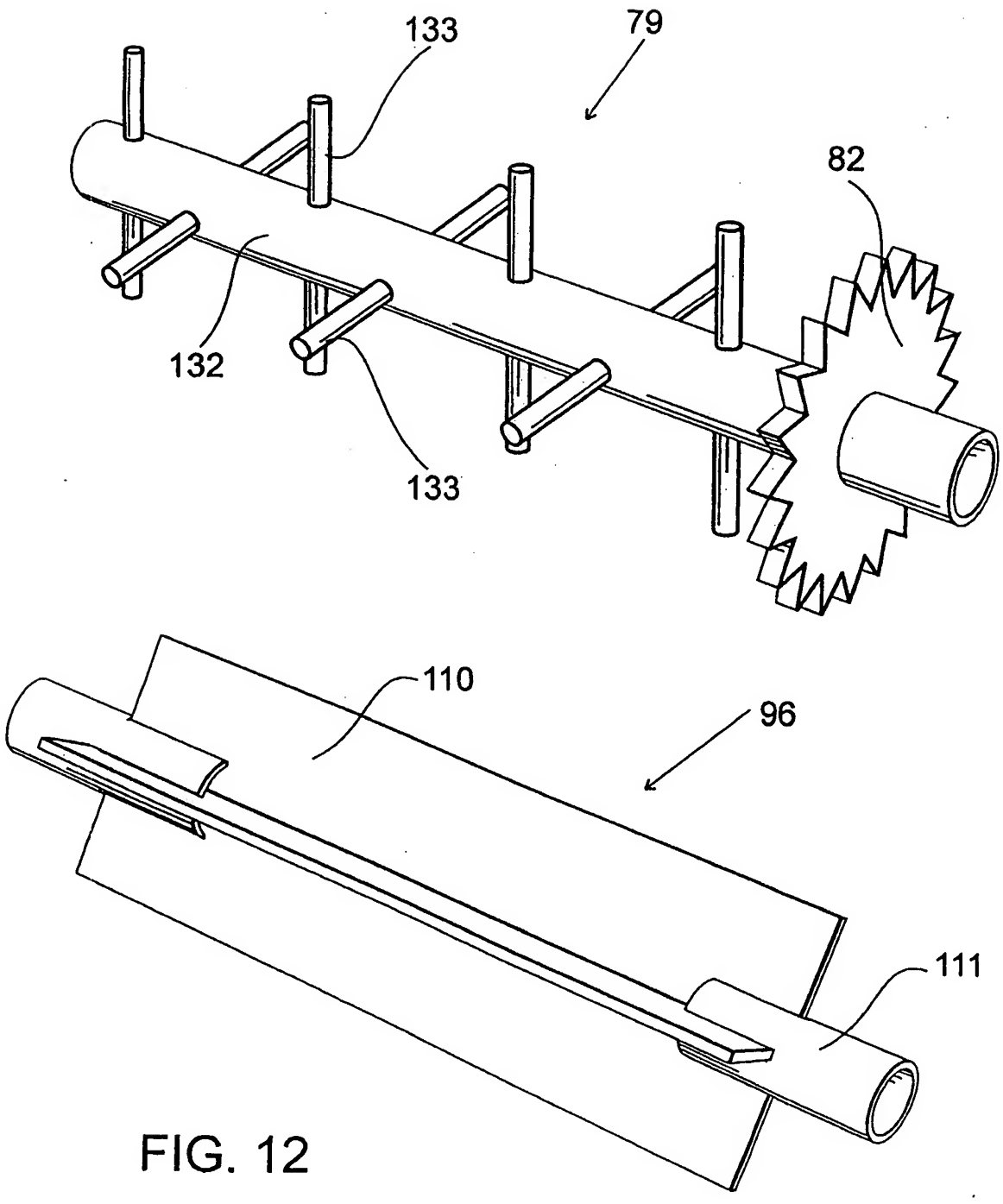

FIG. 12